MAY 7 - 1932

METAL PROGRESS

MAY 1932

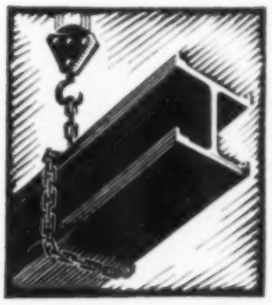
JUST A SIXTEENTH OF AN INCH..

• A prominent producer of automotive drop forgings . . . and an epidemic of seam-like defects in connecting rods. Naturally, the trouble was blamed on seamy stock. • Promptly Republic Metallurgists stepped into the plant. After a check up of the forging and heat treating practice, the Republic Metallurgists started at the beginning—the stock pile. Bars were picked at random . . pickled . . ground. Examined and found absolutely free from seams, these bars were heated and placed in the die. First impression? O. K. Second impression? The same old trouble—a lapping over, seam-like defect in one corner. • Careful study of the defects . . . tireless experimenting in the forge shop . . . and the solution: the section was too thin. Instead of the metal flowing properly under the hammer it "buckled" or lapped. • On the recommendation of the Republic Metallurgists the contour of the forging was changed slightly, about a sixteenth of an inch of metal being added in one corner. When this change was made, the metal flowed freely, the trouble was eliminated and the scrap pile dwindled. • Metallurgists with years of experience in the development of alloy steels . . . all that these men have learned in the study of thousands of steel problems . . . the facilities of the largest and best-equipped laboratories in the American steel industry—these are at your disposal. Avail yourself of them.

Data of help to every buyer and user of alloy steels is contained in the new edition of the Agathon Alloy Steels Handbook. Write for a copy.

CENTRAL ALLOY DIVISION
REPUBLIC STEEL
CORPORATION
Massillon, Ohio

AGATHON ALLOY STEELS



METAL PROGRESS

Published and Copyrighted 1932, by the **American Society for Steel Treating**, *7016 Euclid Ave., Cleveland, Ohio. Issued Monthly. Subscription $5.00 a year. Entered as second class matter, Feb. 7, 1921, at the post-office at Cleveland, Ohio, under the Act of March 3, 1870.*

MAY, 1932 VOL. 21 No. 5

TABLE OF CONTENTS

WHITE METAL 24

MODERN ARCHITECTURE 25

ABNORMAL STEEL 30

BIG PIPE 34

NITROGEN HARDENING 40

SPECIFICATIONS 44

PRESS WORK 46

CAST IRON 49

BALANCE STAFFS 55

BISMUTH 61

POLISH 72

Authors' Page 12

Editorial 47

Data Sheet

Fusible Alloys 65

Correspondence 67

Concentrates 76

Industrial Publications 86

Patents 88

Advertising Index 98

American Society for Steel Treating *is not responsible for statements or opinions printed in this publication. Editorials are written by the editor and represent his views. He is also sponsor for unsigned and staff articles.*

Ernest E. Thum, Editor

Owned and Published by

AMERICAN SOCIETY for STEEL TREATING

Grain Size Control is the outstanding advantage of "Timken Nickel-Moly" Steels

The results are: Excellent forging qualities. Uniform and improved machinability. Minimum distortion during heat treatment. Improved finish. Greater tooth strength.

Better gears at lower cost

Timken metallurgists will welcome the opportunity to prove the value of grain size control in Timken Nickel-Moly Steels as applied to your product.

THE TIMKEN STEEL AND TUBE COMPANY, CANTON, OHIO

Detroit Chicago New York Los Angeles Boston

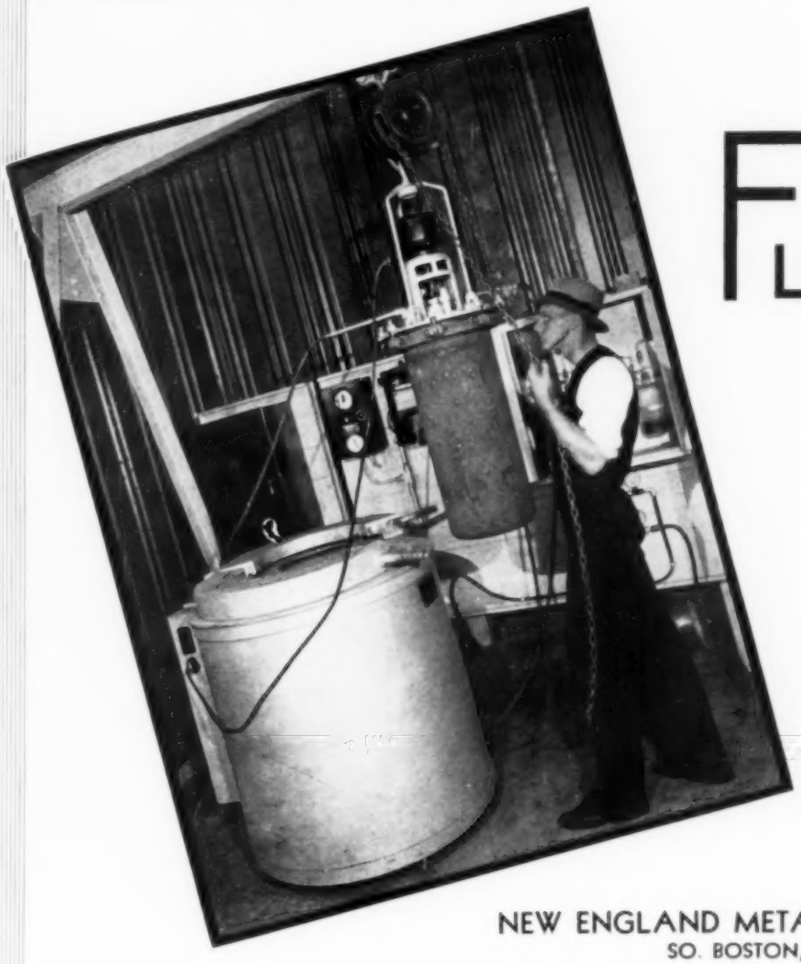
GOOD WILL BASED ON GOOD STEEL

TIMKEN

Electric Furnace and Open Hearth

ALLOY STEELS

ELECTRIC CARBONOL FURNACES



FLEXIBILITY

(NITRIDING)

•

(CARBURIZING)

•

(etc.)

NEW ENGLAND METALLURGICAL CO.
SO. BOSTON, MASS.

This commercial Heat Treating Company must meet the exacting demands of many applications. Their service to the various industries requires flexibility of equipment so there will be no delay in prompt delivery of a quality product. . . . . The application of their Hevi-Duty Carbonol Furnace to carburizing, nitriding, annealing and hardening, enables them to meet the demands of their customers. . . . . Write us for Bulletin No. 931. It gives complete information on the Carbonol Furnace.

TRADE MARK
HEVI DUTY
REG. U. S. PAT. OFF.

HEVI DUTY ELECTRIC COMPANY
MILWAUKEE, WIS.
BRANCH OFFICES IN PRINCIPAL CITIES
In Europe: G. W. B. Electric Furnaces, Ltd., London

AUTHORS AND SUBJECTS IN THIS ISSUE

J. A. Reinhardt

Willard Roth

F. M. Randlett

K. R. Van Horn

The modern theater described on page 25 was designed by the author, GEORGE KEISTER of New York. Mr. Keister, a graduate of Cornell, has practiced architecture and engineering since 1882. He is recognized as a leader in theater design and construction.

Abnormal steels are discussed on page 30 by DR. F. DUFTSCHMID of Oppau, Germany and DR. EDOUARD HOUDREMONT, assistant superintendent of the Krupp works at Essen.

G. O. CARTER, consulting engineer for Linde Air Products Co., wrote the article on long distance pipe lines on page 34.

Nitriding is a specialty of WILLARD ROTH, industrial heating engineer at the Westinghouse plant in Mansfield, Ohio, who describes a bell-type nitriding furnace on page 40 of this issue. Mr. Roth holds the degree of B.S. in E.E. from Ohio Northern University.

F. M. RANDLETT, author of the article on specifications on page 44, is a graduate of Tufts College. He is an electrical and civil engineer and has practiced on the west coast for 27 years. Since 1925 he has been Pacific Coast manager for R. W. Hunt Co.

The discussion of improved cast iron on page 49 was written by OLIVER SMALLEY, general manager of the Meehanite Corp. and director of research of Gray Iron Institute.

The story of balance staffs is told on page 55 by the chief engineer of Western Clock Co., J. A. REINHARDT, who has been with that company since 1919. After graduating from University of Wisconsin, Mr. Reinhardt spent two years at the Bureau of Standards.

Bismuth has interested WALTER C. SMITH, metallurgist of Cerro de Pasco Copper Co., for many years. He has told what he knows of this metal on page 61.

WELTON J. CROOK, who has described a new polishing powder for metallographic specimens on page 72, was born in Australia, but came to Stanford in 1908 to study metallurgy and mining. After an extensive industrial career he returned to Stanford as professor of metallurgy. W. R. PHILBROOK, co-author of this article, is a graduate student at the university.

The data sheet on fusible alloys, page 65, was compiled for the Non-Ferrous Data Sheets of the A.S.S.T. and the Institute of Metals by DR. KENT R. VAN HORN, research metallurgist of Aluminum Co. of America. Dr. Van Horn graduated from Case School in 1926 and received his Ph.D. three years later at Yale.

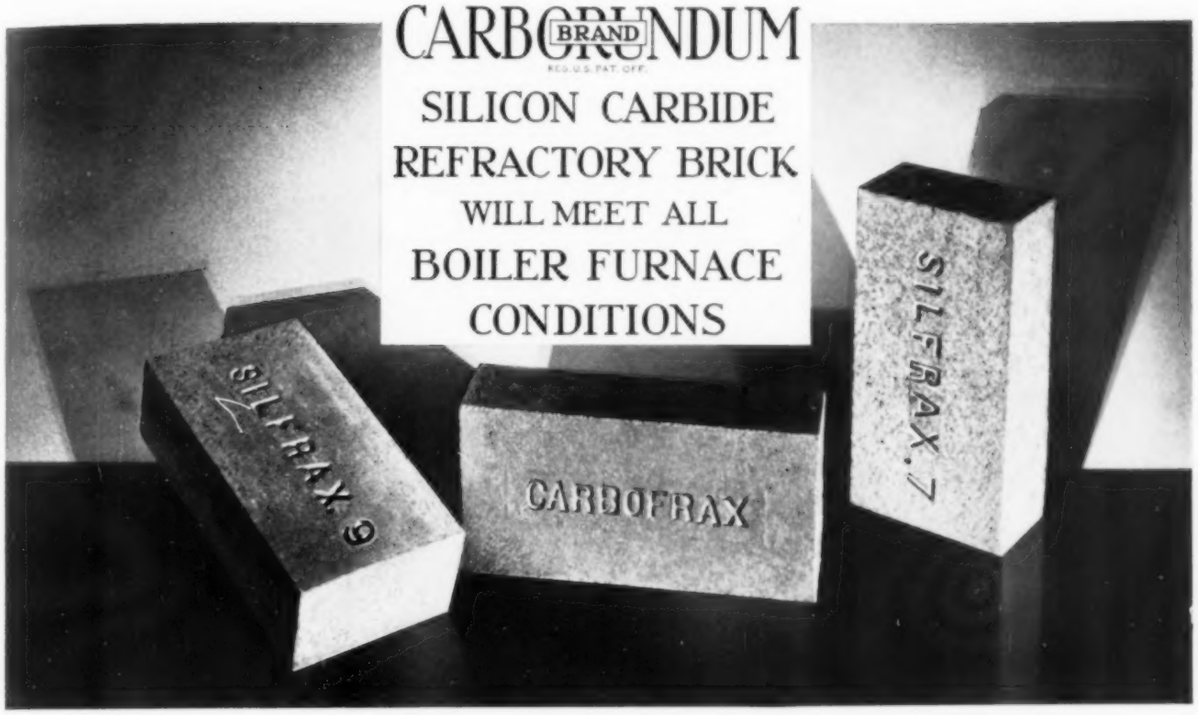
YOU CAN REST ASSURED

• • • • THAT • • • •

CARBORUNDUM BRAND

REG. U.S. PAT. OFF.

SILICON CARBIDE REFRACTORY BRICK WILL MEET ALL BOILER FURNACE CONDITIONS



As the originators and largest manufacturers of silicon carbide refractories, we are in a position to supply these materials in any grade necessary to meet the requirements of a specific installation.

Type and quantity of bonding material, percentage and treatment of original Carborundum Brand Silicon Carbide Grain, processing and burning methods, all serve to fix the characteristics of the finished product.

In boiler furnace refractory practice, the use of our "Carbofrax," "Silfrax 9," or "Silfrax 7" Brick is recommended.

"Carbofrax"

is used to withstand the most severe conditions of service. It contains the highest possible percentage of silicon carbide, and is unequalled in refractoriness, thermal conductivity, and resistance to spalling and clinker adhesion.

"Silfrax 9"

is slightly lower in silicon carbide content than "Carbofrax" and is therefore somewhat less high in refractoriness. It will satisfactorily withstand the service conditions met with in most boiler furnaces and can be supplied at lower cost than "Carbofrax."

"Silfrax 7"

contains less silicon carbide than "Silfrax 9" due to the addition of clay bonding material and is a lower priced brick. It gives excellent service in installations where fireclay brick are not suitable and the more expensive silicon carbide brick are hardly justified.

Permit our engineers to recommend the most suitable and economical variation to meet your needs

THE CARBORUNDUM COMPANY • PERTH AMBOY, N. J.

(REFRACTORY DIVISION)

CHRISTY FIREBRICK COMPANY, ST. LOUIS, KANSAS CITY, NEW ORLEANS, HOUSTON — PACIFIC ABRASIVE SUPPLY CO., LOS ANGELES, SAN FRANCISCO, SEATTLE

DENVER FIRECLAY CO., EL PASO, TEXAS — HARRISON & COMPANY, SALT LAKE CITY, UTAH — WILLIAMS & WILSON, LTD., MONTREAL TORONTO, CANADA

(CARBORUNDUM AND BRAND ARE REGISTERED TRADE MARKS OF THE CARBORUNDUM COMPANY)

Photo by Irving Browning, N. Y.

Aluminum
Stainless Steel
Chromium Plate
Adorn Earl Carroll Theater

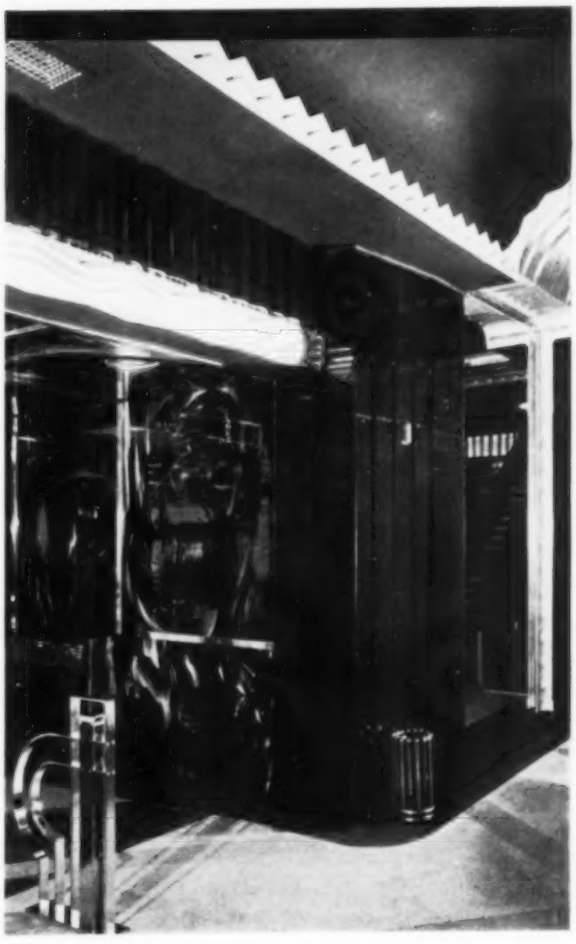
MODERN METALS FOR DECORATING

A MODERN

PLAY HOUSE

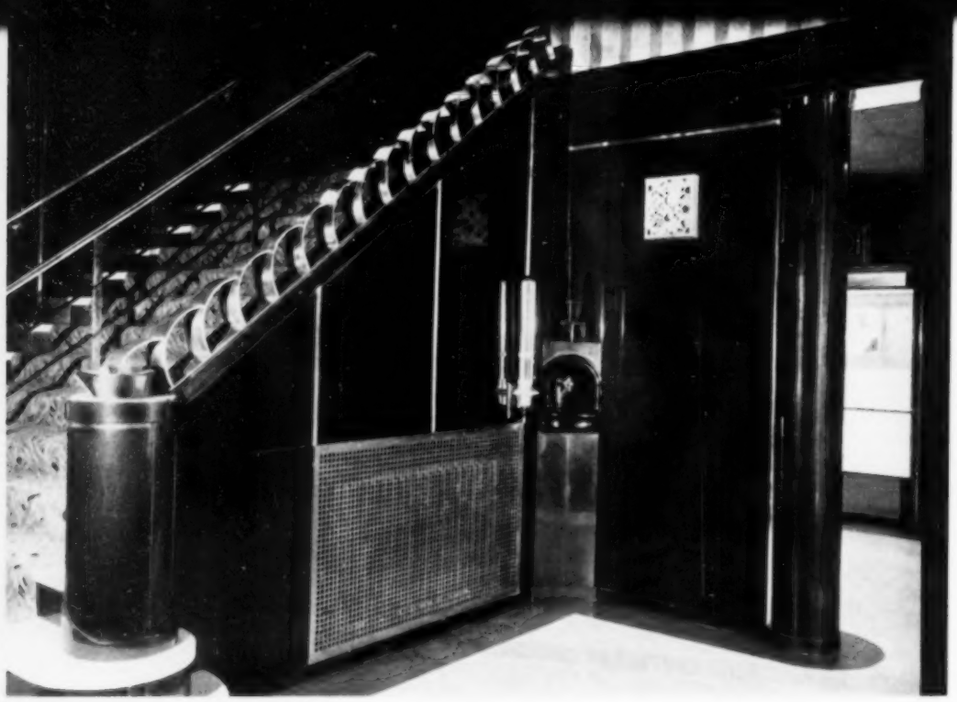
By George Kester
Architect
New York

Photos and Cover by Irving Browning



IT HAS BEEN pointed out many times that the architect today has many building materials unknown a short generation ago and his art has become correspondingly richer. In a sincere effort to meet the needs of contemporary life, especially in crowded centers of population, and to use these new building materials as their respective nature suggests and to the extent their inherent properties permit (rather than in imitation of older structures made of brick, stone, and wood), a new style of architecture has been evolved almost simultaneously and more or less independently in several different countries. These facts warrant its name: "International Style."

Many intelligent Americans think first of "International Style" in terms of the external form of the block-like buildings evolved in accordance with the above-mentioned trends. Nevertheless, the same general principles concerning appropriate use of the new materials should also govern the design of interior construction and decoration. A brief description of the Earl Carroll theater in New York will serve to illustrate this point. For this structure the



writer served as architect; J. J. Babolnay cooperated in the design.

On this stage were to be presented reviews and spectacles utilizing the latest developments in scenery, properties, and lighting. It was felt that a fitting introduction would be through a lobby and foyer with high contrasts — consequently highly polished black and white, the most extreme of contrasts, were utilized. In the auditorium itself the same contrast, between a black velvet background and white strips of light, was to be tempered with gray and some broad bands of delicate color.

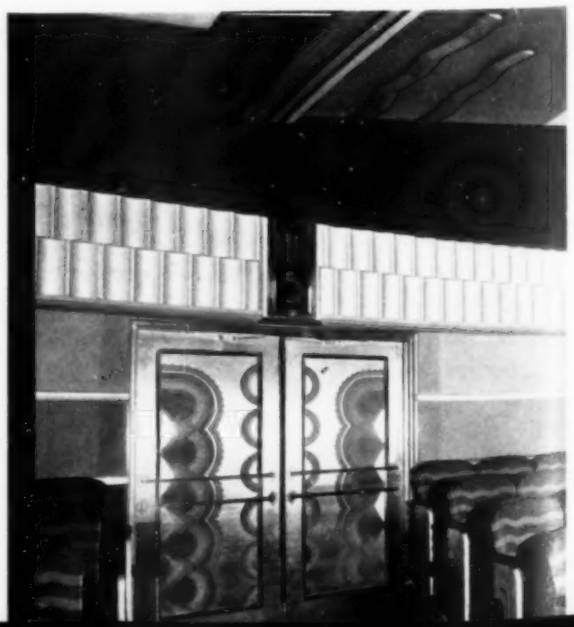
Once this general idea was fixed, the means wherewith to execute it were considered. Chromium plate, chromium steel, chromium-nickel steel, aluminum would all give the white color desired, and be far more suitable than any painted imitation for two reasons, (*a*) permanence and (*b*) ability to retain a polish.

Maintenance of all parts of any new building which are to come in daily contact with 3000 pairs of feet and hands is something which must be carefully considered in advance. All such areas must be washed continually; even the best of paint would not resist such treatment more than a few weeks. Furthermore, a broad, painted surface, even if it could be kept glossy, does not reflect the lights and scintillate with passing life, as does polished metal. Such considerations indicate that unless the decorations are rapidly to degenerate into tawdry affairs, all parts which are within reach of fingers must be made of materials having a permanent surface, hard and smooth.

This necessity of washing for sanitation had an important influence on the choice of the metal to be used. Experience has indicated that chromium-nickel steel of the 18-8 variety will retain its original luster indefinitely in city atmosphere if washed with simple soap and water. In this characteristic it is like clear or colored glass, and consequently the two may be worked together with assurance that the effects originally achieved will endure. High chromium-nickel alloy is superior to some of the plain chromium steels used for architectural trim; the latter are not immune from a light tarnish. Among the other possibilities is aluminum; it does not tarnish, but it must be cleaned with oils, and it is the general experience that oils slowly change the color and luster of the polished metal. Lastly, while a really durable chromium plate is no doubt possible, it is rarely a commercial product.

For the reasons outlined above, the doors, railings, moldings, lighting fixtures, and other silvery trim in the entrance lobby of the Earl Carroll theater are made of 18-8 alloy, highly polished. The walls and ceiling generally are covered with "vitrolite," slabs of black glass with a little brown coloration or veining suggestive of onyx. Vertical and horizontal joints between slabs are covered with rectangular molding about 2 in. wide by ¼ in. high, made of chromium-nickel strip, bent to shape.

As can be seen in the engraving on page 25, all these brightly polished surfaces give back



innumerable reflections, and multiply the animation of the entering patrons. It is part of the "ballyhoo" to quicken their anticipations.

Past this lobby, into the foyers and lounges, the reflections are more subdued. Walls again are made of a black artificial stone called "burkstone." (This is made by casting against a polished mold and therefore it has a very smooth, though dull, surface.) All joints between these slabs are also covered by the 18-8 molding, giving wonderful contrast and also hiding the irregularities from a truly plane surface caused by minor warping when these artificial building stones are cured.

large sheets of steel, about 4x8 ft. in dimension, one for each side. They are not very highly polished—about 200 grit was used on the last wheel. A rectangular area is cut from the center, and the design made by sand blasting the different areas with one of four sizes of sand. Molding on this door panel is buffed and polished to a mirror finish. Hardware (hinges, handles, checks) is chromium plated brass — which, of course, has its own characteristic color. It should be mentioned that the auditorium side of all doors is considerably duller in the grade of polish than the foyer side, so as to prevent a number of distracting reflections

The above-mentioned moldings are attached to hardwood furring strips by hooks spot welded to the rear side. All handrails, ballustrades and doors are also of 18-8 sheet and strip. Ability to weld this material is a prime advantage to the builder. Joints at the door corners are welded, then polished, and are then indistinguishable from the rest of the sheet.

Beautiful contrasts in 18-8 are to be had by merely changing the luster. A door, such as shown in the view opposite, is made of two

into the eyes of the seated audience.

Such simple means offer almost limitless possibilities for the artist and skilled artisan. Best of all, its superior result — once achieved — is as permanent as anything we have so far produced.

Various thicknesses of 18-8 were used in this work, ranging from $\frac{3}{8}$ in. to 30 gage. Most of it was about 20 gage; slightly heavier weights should be used toward the floors, where it may be kicked or hit by moving furniture; at eleva-

Green Carpets and Ceiling, Black Walls, Silvery Lamps Pillars and Furniture Trim Produce High Contrast

tions above 6 or 7 ft. the wall decorations can be made considerably lighter — the higher up you get the stronger is the temptation to use chromium plate, if the color could be made to match.

This matter of color matching is given an extra amount of attention by the architect — that is to say, the steel manufacturer contends that the architect is too fussy; the architect doesn't think he is! As a matter of fact, there is no good way to specify color and surface luster on polished metals; a lot of metal may seem to match a small sample perfectly, but be quite easily distinguishable when a broad area is erected as interior or exterior trim. For that reason the bill of material of 18-8 for this entire theater was ordered and furnished from one furnace melt, and several spare pieces of each gage kept in reserve against the possibility that some metal might be spoiled in fabrication.

Returning now to a consideration of the decorative value of the metal: Black and white contrast in the foyers is further enhanced by covering the plaster cornice, placed above the dull burkstone wall slabs, with aluminum foil.

This thin metal is also used very extensively in the auditorium itself. For instance, the massive pillars at either side of the proscenium opening, the arch itself, and broad bands of decoration on ceiling and side walls are covered with foil. Here it not only gives a high contrast with the black velvet covering walls and ceiling when the lights are white or yellowish, but it has the ability to reflect any other color.

In fact, the reflecting qualities of aluminum foil are so good that it is used in the entire house-lighting system. All lighting is "indirect." The principle is illustrated in the view of a detail of the construction shown below. It will be observed that the ceiling is deeply recessed; this entire cavity and the side ornamentation are covered with aluminum foil to tone with the cornice. Down the center of this recess and more or less flush with the rest of the ceiling is a metal trough, made of aluminum sheet, the angles of which are set to scatter effectively the light of incandescent bulbs hidden above and behind them. Nine such broad recesses occupy the ceiling of the main auditorium, extending from curtain to rear of the house. Side walls each have six broad geometric developments of similar construction for lighting, and render the striking effect shown in the frontispiece.

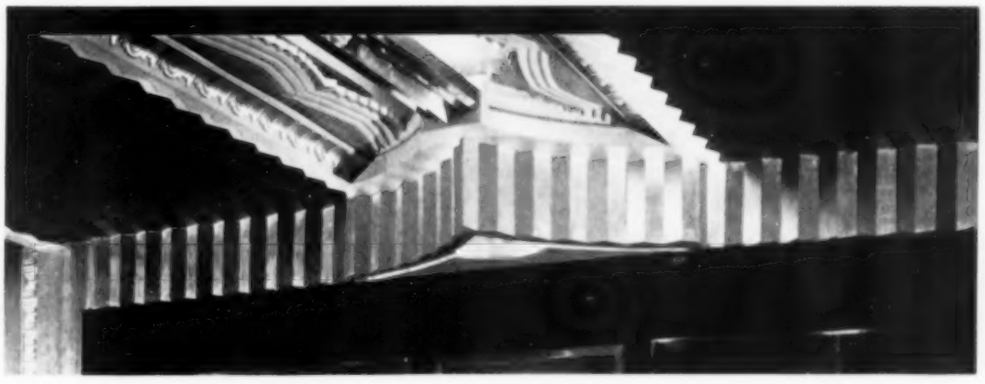
All banks of such lights have lamps of four primary colors, and every such circuit is wired to a central control board called a "light console" located just behind the musical director. By means of vacuum tubes all degrees of intensity of illumination in any circuit may be imposed, either singly or in combination. Resultant mixtures range from one end of the spectrum to the other, and are reflected so well that the aluminum-covered plaster looks as though it were translucent glass of continually changing hue.

Original plans called for 18-8 metal in all railings and fixtures in the auditorium, but this was later changed to chromium plated brass to keep within the appropriation — a move which is justified by the relatively small amount of abuse such fittings will get. Bright parts of exit-lights are plated. Much plated metal is found in the furnishings and floor lamps.

The photograph on the front cover and the one on page 27 do justice to the effects created with the new constructional materials, and go to prove the statement made at the outset about modern architecture and decoration, namely, that they can be used effectively in a characteristic manner, and not as a mere imitation of wood, stone or plaster. The statue is in a niche in the stairway leading up from the mezzanine lounge shown opposite; its sloping ceiling is formed by the balcony supports; its height is enhanced by covering the massive columns with aluminum foil, and the breadth is doubled by covering the rear wall with enormous mirrors. Ceiling is olive green, supplementing the deeper green carpet. Stair balustrades are gleaming 18-8. In the niche is a decorative fountain with black marble base and chromium plated fluted pedestal. The statue is of plastic, covered with bronze leaf. Background is painted plaster; the niche is framed in aluminum sheet.

Metal has also caught the fancy of the theatrical producer; "platinum," "gold," "silver" appearing frequently on the program at the Earl Carroll theater. Very striking metallic effects are continually produced on the stage. These, of course, are mostly illusions, but nevertheless are but indications of the eye appeal of metal.

Aluminum Foil is Used on Cornice & LightWells in Ceiling; Aluminum Sheet to Hide Bulbs



PUREST STEELS DEVELOP SOFT SPOTS IF CARBURIZED AND QUENCHED

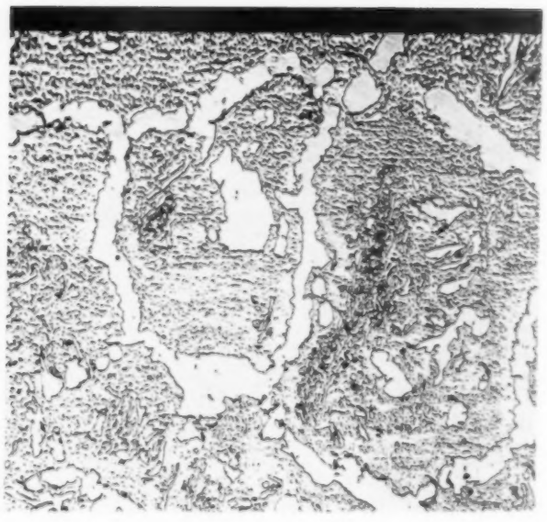
By Dr. F. Duftschmid
Oppau, Germany
and Dr. Edouard Houdremont
Assistant Superintendent
Krupp Works, Essen

MUCH literature on the question "normal vs. abnormal steel" has appeared (especially in the *Transactions* of the American Society for Steel Treating) since 1922, when H. W. McQuaid and E. W. Ehn presented their noteworthy papers on the effect of quality of steel on case carburizing results.

It will be remembered that the surface layers of "normal" steel, after carburizing at 1700° F., exhibit a sharply defined straight-lined cementite network and a rather coarse-grained structure, whereas the cementite of "abnormal" steel coagulates extensively, not only in the hyper-eutectoid case, but also in the pearlite of the core. Abnormal steel also has a fine grain. On quenching cemented articles at the standard rate of cooling, those made of abnormal steel tend to develop soft spots while those made of normal steel harden uniformly.

So-called abnormal behavior has been blamed frequently on some alloying element or specific contamination. Messrs. McQuaid and Ehn originally advanced the hypothesis that abnormal behavior during carburizing and quenching was due to oxides uniformly distributed in solid solution in the steel, and hence the defect originated in improper steel manufacturing practice. The fact that rimming steel (especially that which has been killed at the last

Figure 1



A Mass of Carbonyl Iron After Carburizing 6 Hr. at 1750° F. Magnified 300 diameters. Agglomeration of excess cementite indicates "abnormal" nature of purest iron

moment in the ingot mold itself) frequently shows pronounced abnormality gave further weight to this hypothesis.

Actual oxygen determinations, however, have failed to justify this supposition. Dr. Grossmann, for instance, in the 1930 Campbell Memorial Lecture (METAL PROGRESS, Nov. 1930), endeavored to show that the abnormal behavior of steel is due not only to the oxygen originally present in the steel, but to the oxygen which

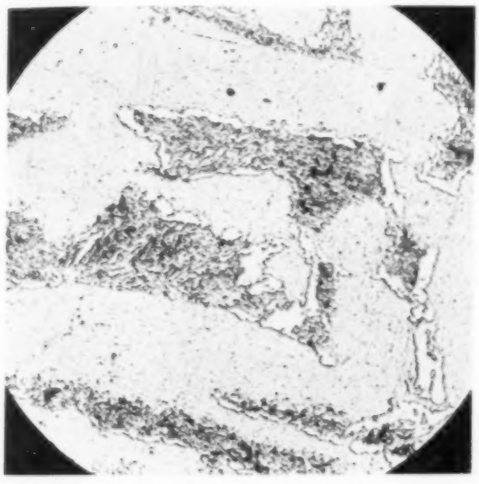


Figure 2

Structure of Synthetic Steel (0.60% C) of Highest Purity. Magnified 200 diameters. Abnormality of cementite particles bordering pearlite areas

penetrates into the surface layer in the course of the commercial carburizing processes, and that abnormal steels possess greater dissolving power for oxygen. Oxygen pick-up, of course, fails to account for the fact that structural abnormality also occurs in the pearlite of the core portion of abnormal steel, far below the surface.

A comprehensive survey of the literature was published in *Stahl und Eisen* for Dec. 31, 1931, wherein the reviewer supported the conclusion that the difference in structure was due to differences in the critical point on heating and cooling. In order to clarify this point, and to study the action of oxygen-free steel, the present authors experimented with some synthetic iron-carbon alloys of highest purity. We made our alloys from natural gas carbon and electrolytic iron or powdered iron obtained by the carbonyl process. (The latter process is patterned after the Mond nickel process; iron filings are exposed to CO gas at moderate temperature, whereupon a gaseous iron-carbonyl is formed, later to be decomposed in another chamber at a higher temperature.)

Of particular interest are the investigations on carbonyl iron, because we can not only carburize it (that is, allow the carbon to penetrate from the outside) but also, by sintering and forging mixtures of powdered carbonyl iron and sooty carbon, produce high carbon carbonyl steels, in which the carbon has penetrated into the minute particles of pure iron by diffusion at elevated temperature during the sintering process.

When pure electrolytic or pure carbonyl iron is carburized, the typically abnormal structure of cementite shown in the first photomicrograph exists at the surface. However, carburized carbonyl iron did not have a particularly fine grain, such as is invariably attributed to abnormal steel in the existing literature. On the contrary, this iron, which is produced without melting, appears to possess quite exceptional crystallizing properties, probably owing to the absence of boundary films that are present in all steel manufactured by fusion processes. A cross-section of a carburized round bar, 1½ in. diameter, will show a steel case about ⅛ in. thick, but the entire core consists of about a dozen large crystals of pure iron. From this it would appear that fine grain is not always associated with the structural abnormality evidenced by the separation of cementite and ferrite, but merely represents an accidental coincidence occurring in the steels described in the existing literature.

Our synthetic steels were made as follows: Pressed mixtures of pulverized carbonyl iron and purest carbon gas soot were sintered for 3 hr. at 1925° F. The sintered blocks were then forged into square bars under a steam hammer. Each steel was examined both in the forged and in the normalized state. Normalizing was effected by holding the specimens for 30 min. at a temperature from 35 to 55° F. above the upper critical point and allowing them to cool in air.

Four steels were made, containing 0.60, 0.85, 1.15, and 1.40% carbon respectively. In the forged and normalized state the 0.60% carbon steel, whose structure would be expected to be pearlite areas in ferrite network, had an ab-

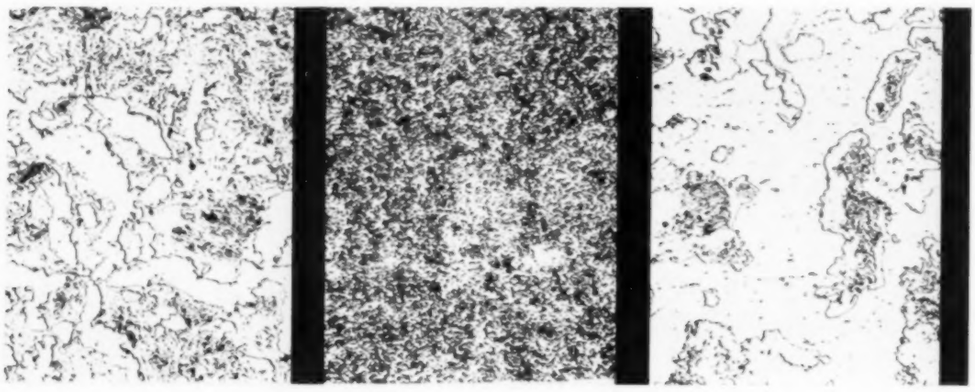
normal agglomeration of cementite at the edges of the pearlite areas, as shown in Fig. 2. The steel with 0.85% carbon showed a sorbitic structure which might be found in any good eutectoid steel. Both the high carbon steels were decidedly abnormal, and looked much like Fig. 1, although the cementite was broken up in larger, rounder masses.

It would therefore appear that all sintered carbonyl steels show abnormal microstructure, except the eutectoid steel containing 0.85% C. It will be remembered that these are especially pure alloys. Consequently, the large accumulations of cementite may be due to a deficiency of crystallization centers existing during the temperature range wherein pearlite is forming from the solid solution. More evidence on this point was found later.

eration of cementite in case and core requires a high rate of crystallization and a small number of nuclei, conditions present in the segregated cementite and also at the pearlite grain boundaries. On the other hand, in the eutectoid transition zone a great number of nuclei suddenly appear during transformation and cause fine crystallization, that is, the formation of normal sorbite or fine pearlite.

As a conclusive proof of this point, the eutectoid steel containing 0.85% C was also decarburized. It then had an abnormal microstructure in the case exactly like Fig. 5. All the carbonyl carbon steels produced by the sintering process therefore show the same abnormal behavior as cemented carbonyl and electrolytic irons.

Annealing in a nitrogen atmosphere at 1925° F. did not result in any change in behavior



Core, Transition and Case of Decarburized Sample of 1.40% Carbon Steel. All magnified 300 diameters. Transition zone only has normal crystallization

Figure 3 **Figure 4** **Figure 5**

It seemed peculiar that synthetic pure steels should have a normal sorbite at the eutectoid composition, but have segregated cementite when carbon is higher or lower. We determined to produce samples containing the three zones in a single steel, and see what happened. For this purpose, a sintered carbonyl steel containing 1.4% C was decarburized in such a manner that the core remained hyper-eutectoid, while the surface layer became hypo-eutectoid. Figures 3, 4 and 5 show the structures. It is clearly seen that the conditions parallel those found in the synthetic steels of similar carbon content, and whereas this one exhibits typical abnormal behavior, the eutectoid zone does not seem to be infected with the trouble. This is not surprising, considering that the coarse agglom-

of these synthetic steels. After annealing 5 hr. in a vacuum at 2285° F. and subsequent annealing at 1925° F. in nitrogen, the excess constituent (cementite in the hyper-euctetoid steels and ferrite in the hypo-eutectoid) arranged itself along octahedral planes and built up a Widmanstätten structure, but even so the cementite plates were not continuous, but broken up into elongated particles with rounded boundaries, thus continuing to show abnormal coagulation. Neither could a fundamental change in structure be obtained by quenching from 1925° F. The hardened structure consists of martensite-troostite, which is associated with the tendency to form soft spots. Annealing subsequent to quenching restores abnormal microstructure.

Forging subsequent to an anneal at 2000° F.

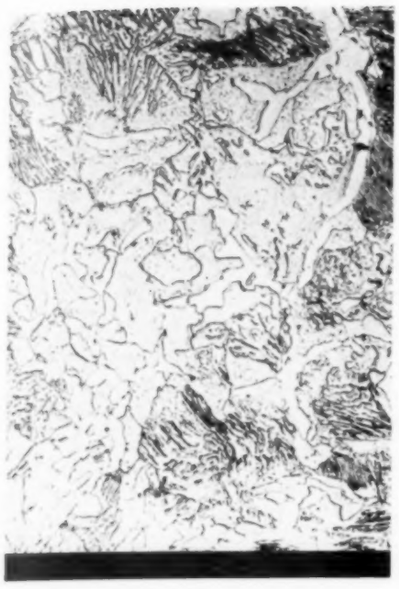


Figure 6

Carbonyl Steels (0.80% C) Melted in Vacuo With no Manganese and With 0.30% Manganese, Respectively. After carburizing six hours at 1750° F., the former has an abnormal case, the latter a normal one. Magnification 300 diameters

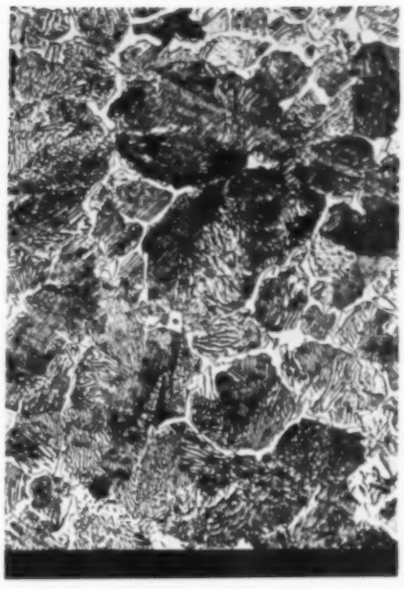


Figure 7

also failed to produce a fundamental change in structure.

As might be expected from this abnormal behavior, when these carbonyl steels were hardened, all developed soft spots when quenched in water, whereas perfectly uniform hardening is obtained when quenched in salt water. This statement is equally true of cemented specimens of carbonyl iron and electrolytic iron.

In order to make sure that this peculiar behavior of these iron-carbon alloys is really a consequence of the purity of the steel and is not due to the sintering process (which somewhat resembles the cementing process), a number of steels was manufactured from carbonyl iron by fusion. These steels exhibited the same abnormal behavior, that is, an agglomeration of cementite and tendency to develop soft spots in hardening. Microstructure of the high carbon case can hardly be distinguished from that shown in Fig. 1.

The oxygen content of all these steels, especially the sintered ones, was easy to determine, owing to the absence of stable oxides, and was found to vary from 0.0008 to 0.001%. Impurities of this order of magnitude cannot be held responsible for the abnormal behavior of the steel. Absorption of oxygen during cementation, Dr. Grossmann's supposition, hardly enters into the question, since the steels manufactured by the sintering and fusion processes were not case hardened, yet were thoroughly abnormal, and very low in oxygen, by analysis. Furthermore, high temperature annealing in a vacuum, which might be expected to remove any undiscovered dissolved gas, especially in the surface layers, also failed to cause a fundamental change in the behavior.

The result of all these investigations goes to prove that the different varieties of pure iron and steel show a strong tendency toward abnormality, as defined by McQuaid and Ehn.

This is a result quite contrary to the generally held ideas concerning the fundamental cause of soft spots on carburized work (at least, as judged from the American publications on the subject). It would be well, then, if a logical explanation of the coarse crystallizing tendency of oxygen-free steels could be presented.

It follows from the fundamental phase rule, and the conditions as set forth in the iron-carbon equilibrium diagram, that heavy agglomeration of the cementite in abnormal steels cannot set in until after complete transformation below A_1. As already mentioned, the prerequisite to abnormal microstructure is a rapid rate of crystallization. The latter occurs when the transformation corresponding to Ar_1 takes place at a very high temperature, thus providing the maximum atomic mobility. Heating and cooling curves on one of our high carbon synthetic steels show extremely sharp *(Continued on Page 92)*

LARGE PIPE, STRONG STEEL, 100% JOINTS HAVE A PROFOUND EFFECT ON INDUSTRY

By G. O. Carter
Consulting Engineer
Linde Air Products Co.
New York City

IN a pair of articles published in METAL PROGRESS about a year ago, G. P. McNiff of National Tube Co. gave the history of seamless tubing. Seamless tubes, particularly those of large diameter, are the culmination of the efforts of a generation of engineers; some have been perfecting the pipe making process; others have been aiming at the tonnage production of high strength steel. The advance may be appraised by comparing the soft steel (carbon 0.08 to 0.12%) required for butt and lap welded pipe up to 20 in. diameter with the low alloy steel containing 0.30% carbon and 1.50% manganese commonly used for seamless, now available as large as 24 in. diameter. The soft steel has an average ultimate strength of 55,000 lb. per sq. in.; the medium manganese steel will pull at 80,000 to 90,000 lb. per sq.in.

Such movements as these have been in response to definite demands from the consumers. To fulfill these demands, the pipe mills have undergone revolutionary changes. Similar profound changes have occurred in the production and marketing of petroleum and natural gas. All have had marked effect on business structure in America. It is the purpose of this article to sketch these relationships. The development of high pressure pipe lines has been so quiet from the technical aspect that it has been practically overlooked by metallurgists, although, as already noted, the production of this type of pipe line has had a far-reaching effect on our domestic economy.

Ten years ago, when the writer outlined the possibilities of high pressure transmission of gas and dared talk of 1000-lb. pressures in 16-in. pipe, his audience (engineers in the gas industry) considered such a plan impractical, particularly because he advocated the construction of lines many hundred miles in length.

In the original outline it was contemplated that the 16-in. pipe should be of seamless construction, and hence would be capable of operation with a lower factor of safety than would be permissible with the old types of lap welded

pipe with mechanical joints, although the increased strength that has since been provided by better steel was not then contemplated. (Light-walled pipe was not being made at that time, so this is also a new development.)

One of the reasons why high pressure lines could be considered was an improvement that eliminated all mechanical joints. I refer to the welding of pipe lengths in the field. This has unquestionably been one of the vital points in the decade's development, although some rather lengthy lines have been built with compression or screwed couplings. The present practice is to weld all joints in pipe lines up to approximately 16 in. diameter. Larger lines are composite, having an occasional mechanical joint or expansion joint.

To show what has been done in this 10-year period I shall mention a few of the notable pipe lines that have received much publicity in trade journals. Pipe line activities of the various "Standard Oil interests" include those built by the Standard Oil Co. of New Jersey for oil, gas and gasoline; the Standard Oil Co. of New York for oil and gas; the Standard Oil Co. of Indiana for oil; Standard Oil Co. of California for oil and gas; the Prairie Pipe Line Co. for oil and the Atlantic Refining Co. for oil. Companies not in the "Standard group" (such as the Empire Co., Shell, Gulf Petroleum Co., Texas Co., Sinclair Oil Co., the Sun Co., Pure Oil, and Barnsdall) have built important oil lines; and such companies as Columbia Gas & Electric, Electric Bond & Share, Cities Service, Mid-West Utilities, Pacific Gas & Electric, Oklahoma Natural Gas, and the Lone Star have developed very extensive systems for transmitting natural gas and mixed natural and artificial gases that compare with the inter-connecting high tension electric lines of the big power groups.

Obviously, there must be some fundamental reasons for this far-flung development of pipe lines, so extensive as to constitute a most important change in our transporation system. Inasmuch as there have been such marked changes in the method of manufacture of pipe and the steel that goes into the pipe, these technical items must have had a very material influence.

When it is realized that approximately half the cost of installing a pipe line is that of the steel itself, it will be appreciated that long pipe lines have been a wonderful source of business for pipe manufacturers. On the other hand, there has been an insistent demand from the purchasers for better pipe for less money. What

Seamless Tubes Entering the Reeling Machines

Courtesy Aetna-Standard Engineering Co.

has occurred may be stated as follows: 24-in. pipe weighing approximately 80 lb. per ft. is now being operated at pressures from 600 to 800 lb. per sq.in. Ten years ago, 16-in. pipe was the largest generally used; it weighed approximately 62.5 lb. per ft. and was operated at a maximum of 300 lb. per sq.in. pressure.

On account of lessened internal friction the carrying capacity of the above-mentioned 24-in. pipe is more than would be expected by the increased area and proportionate increase in pressure. As the ratio of diameters is 3 to 2, the areas are as 9 to 4; since the pressure increase is at least $2\frac{1}{2}$ times, the increased capacity of the modern gas pipe 24 in. in diameter exceeds that of the old 16-in. pipe by the ratio of $5\frac{1}{2}$ to 1. Eighty pounds of steel is therefore carrying more gas today than 340 lb. would have carried 10 years ago.

At the beginning certain engineers saw the economic effect of cutting down the weight of steel. They did so by reducing the wall thickness of the then standard grade of lap welded pipe and protected this thinner pipe carefully, so as to reduce the effect of external corrosion, which was one of the reasons why the thick-walled pipe was specified. Shortly after that time some steel fabricators, who were acquainted with the higher strength materials used in automobile construction, suggested that pipe could be fusion welded of relatively high strength plate, with a minimum of 60,000 lb. per sq.in. tensile strength, instead of the low strength steels necessary for the lap welding process. These two steps (lighter-walled pipe and higher strength pipe) effected about half of the total saving in weight mentioned above and were so important that they warranted the construction of several pipe lines, much longer than any that had been contemplated prior to that period.

These technical changes resulted in a demand for pipe which expanded the manufacturing capacity of the country from the existing total of about four miles a day to a figure in excess of 30 miles a day. (This refers to pipe of large diameter.) Yet the well-financed utility companies were able to plan projects that took all this capacity. This made it well worth while for steel men to consider further improvements, and warranted the development of a process for manufacturing large diameter seamless pipe of an even higher grade of metal. Now that this has been done, steel of 70,000 lb. per sq.in. ultimate strength can be guaranteed, and because of the seamless nature, the pipe can be operated with an even lower factor of safety than any previously manufactured.

This, briefly, is the present state of the art of pipe line construction and of pipe manufacture for long gas lines. Along with the development of steel and the use of light-walled pipe, protective coatings have been devised which are applied in the mill or in the field after the pipe is joined to form the line. Some of these protective coatings are a combination of paint or enamel with paper or fabric wrapping, and have a final sealing paint. Much cooperative work is under way to determine the best protection for steel in the various soils which are encountered in transcontinental lines.

The lines that were laid several years ago are reported to be in very good condition, which indicates that the methods of protecting the steel are generally effective, for in certain of the soils uncoated steel could hardly last two years.

At the beginning of the decade, pipe up to about 20 in. diameter was made by lap welding (rolling over a mandrel). During this period hammer welding, which had been used in manufacturing heavy-walled high pressure equipment, was adapted to the making of thin-walled pipe from 20 in. up; later fusion welding of abutting longitudinal seams in bent plate was introduced and has become a most important factor. Improvements were also made in the process for lap welding pipe and finally equipment was developed for making seamless pipe up to 24 in. diameter. Thus the steel industry is providing better pipe at a lower cost than at the beginning of the period under view.

With the advent of high strength, light-walled pipe for carrying gas the manufacturers also developed lighter and stronger pipe for carrying oil and gasoline, so that most of the long pipe lines which have been laid by the petroleum industry in the past year or two have been made with the high strength steel, a large part of it seamless tube.

Some of the advance in the production of the proper grades of steel may be attributed to the necessity of getting stronger and stronger

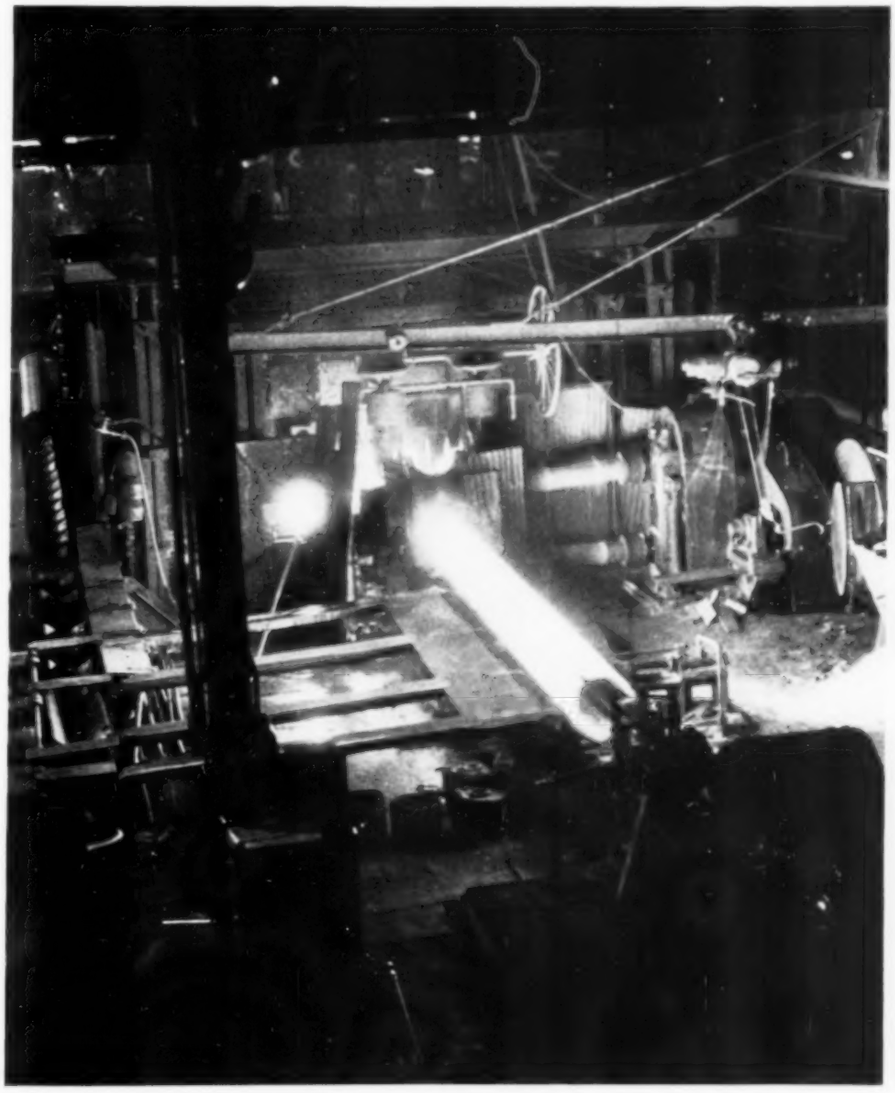
pipe and connections for casing or lining the deeper and deeper wells now being driven to the lower oil horizons. The type of steel that was developed to give this strength was found to be entirely suitable for larger tonnage production and is used to a considerable extent in the manufacture of the above-described pipe lines. In addition to improving the strength of steel, steps were also taken to improve the corrosion resistance. An example of this is the 1% copper steel, which is unquestionably to be considered in the category of alloys. This particular steel is used to a limited extent in oil well equipment.

Application of high strength pipe for deep oil wells has had as important an effect on the industry as have the other uses of pipe described above, because it extended the drilling to the lower producing horizons and brought a flood of oil upon us. This may not be an unmitigated blessing to all, but whatever fault is to be found should be directed toward those who have not been able to restrain themselves in the use of advanced ideas and improved equipment made available to them by engineers and technicians.

One can easily see that the widening popularity of well-protected steel may have quite an important effect upon the sales of cast iron pipe. At the present time steel is ordinarily installed for the high pressure end of many systems, and cast iron in the distribution network within city limits where pressures are usually relatively low.

Another very important item that must be considered in connection with the construction of the long pipe lines is the joining of the lines. At the beginning of this decade, screw joints were standard on pipe sizes of 12 in. and below; rubber-coupled joints were favored for larger sizes such as 14 in. and 16 in. At the present time nearly all of the oil lines and pipe systems below 12 in. diameter have oxy-acetylene welded joints. Lines of larger sized pipe are completely built with oxy-acetylene or elec-

Lap Welded Pipe Emerging From Rolls



Bent Skelp Comes From the Furnace at Welding Heat, and Joint Is Made by Pressure Between Rolls and a Mandrel

Photo by Rittase at Spang - Chalfant's big welded pipe mill

trically welded joints, or have an occasional coupling intended to ease the contraction and expansion due to temperature changes.

Organization of the field crews for welding was quite a problem at first, but this has been thoroughly mastered. There are literally dozens of welding gangs at work simultaneously during the summer and autumn months. The speed of welding and the strength of the welded joints have increased so that today the full strength of the pipe section can be obtained at the welded joint, even though the strength of some of the pipe being laid is double that of 10 years ago. During the past two years there have been some almost phenomenal improvements in oxy-acetylene welding methods, due to the introduction of semi-automatic equipment and changes in the flame, and today a welder can weld twice as many 24-in. pipe joints per day as he could 16-in. joints a few years ago, with an equivalent reduction in welding cost.

Some of the advantages of welding lengths of pipe together may be better appreciated if consideration is given to the troubles encountered with other methods of making the joint. At the advent of field welding the maximum size of oil lines was 12 in., and this size was not a very popular one because of the difficulty of coupling the pipe. Threading removed so much of the steel at the end that it materially weakened the wall if a fairly heavy thread was used. On the other hand, if a fine thread was specified there was a great deal of difficulty from crossing the threads. As the diameters increased this became an even more important problem. Welding permitted the use of lighter weight pipe than had been previously used, and since then a large percentage of oil lines have been 12 in. diameter. Just why this diameter has not been exceeded is hard to determine unless it is that all other equipment, such as tankage and pumps, is made with 12-in. standard connections.

It must be remembered that if there is any leakage at all the loss increases as the pressure increases. Under high operating pressures, scour and friction by escaping fluid are apt to enlarge the opening so that there will be a continuous increase in the losses. Low operating costs and maintenance are therefore on the side of the all-welded line, for it is the only "bottle-tight" one. It is the present practice to place an occasional mechanical joint in the larger diameters to provide for expansion and contraction, or to care for problems arising during laying the line. With developments that are now in sight there seems to be no reason why completely welded lines of any size cannot be built.

Therefore, the welding of these lines, so as to permit operation at high pressure with practically no leakage, has been a most important phase of the development. It has had a bearing on the permissible types of steel, as it is im-

Field Welding Speed Has Been More Than Doubled by Using a Double Flame With Slight Excess of Acetylene and Small Fixture Which Holds Flames, Filler Rod, and Joint in Correct Relative Positions

Making a Joint in a Large Gas Pipe

Equipment for Inspecting Joints

Car Contains Equipment for Cutting Test Pieces Out of Pipe, Vise for Making Bend Tests, and Portable Tensile Test Machine

portant that the metal be weldable by the fusion welding processes. Metallurgists in the welding industry have been active in matching the requirements, and have discovered means for making welds fully equal to the strength of the pipe itself.

This has been quite an achievement, because, even though the guaranteed minimum strength may be 70,000 lb. per sq.in., the steel manufacturer might work steel up to 100,000 lb. per sq.in. strength. For various reasons that are pertinent to the methods of construction of the pipe lines the circumferential welds should be fully as strong as the ultimate strength of the individual sections of pipe that are being joined; it is not enough for the welds to equal the minimum steel requirement. It is therefore significant that metallurgists and welding engineers have been able to supply welding rod and devise welding technique capable of producing joints which develop the full strength of the new pipe.

The grade of steel that is now accepted as supplying the superior strength required for the larger systems has a carbon content of from 0.25 to 0.35% and a manganese content not to exceed 1.50%. To date manufacturers have not heat treated this steel so as to give additional strength but some such treatment is a possibility for the future.

Inasmuch as the manufacture of large diameter pipe now consumes 6 to 8% of the steel ingots made in the United States, it is safe to assert that the above grade of low alloy steel is being produced on a major tonnage basis. As it is materially superior to the average carbon steel used in so many other places, such as for tankage, it will be interesting to see how soon this metallurgical development is applied in other directions. Of course, there are few places where the cost of the steel represents such a high percentage of the total cost of the entire installation or structure, which factor has had such a material bearing on the economics of the oil and gas pipe line industry. Nevertheless, the long-time trend in the use of metals is to adopt that material best suited for the purpose, and this will favor the use of alloys.

A Tested Weld

Test Piece Cut from Joint at Random or on Suspicion and Replaced by a Steel Insert

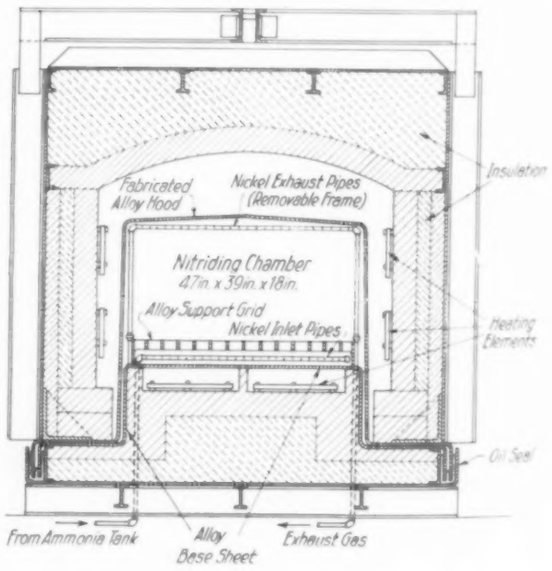
COSTS CUT IN HALF WHEN NITRIDING IN BELL FURNACES

By Willard Roth
Industrial Heating Engineer
Westinghouse Electric & Mfg. Co.
Mansfield, Ohio

THE rapid development of the nitriding art within the past few years is well known to readers of METAL PROGRESS. The nature of "nitrogen case hardening" has been widely discussed, especially by members of the American Society for Steel Treating, and is still the subject of considerable research. The commercial utility of nitrided steels has steadily broadened.

An accompanying evolution in types and sizes of the electric furnaces used has kept pace with these movements. Starting with improvised steel boxes in whatever furnaces were available, nitriding equipment passed through the rapid cycle of changes which now-a-days awaits every successful innovation. Changes were at first designed primarily to improve the quality and uniformity of the product. Later, as the amount of commercial nitriding grew, changes were made to reduce the cost of the process, the electrical energy used, and the amount of labor required, and to increase the productive capacity and life of the equipment.

Efforts toward reducing the unit cost of nitriding are of particular interest, affecting, as they do, the future expansion of the art. Increased production in larger furnaces naturally brings opportunities for reduced costs, yet there have been built, to date, only a few large-scale nitriding units. Results obtained from them have unfolded possibilities in economy which

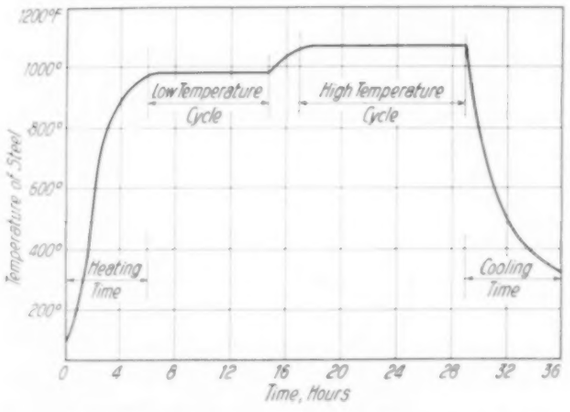


Cross-Sectional Drawing of a Bell-Type Nitriding Furnace

will have an important bearing on future expansion. Since these results should be of general interest, this article gives a description of a nitriding installation for what is yet considered large-scale production.

This equipment is located at the East Springfield, Mass., works of the Westinghouse Electric & Mfg. Co., and it was built early in 1931. It has a capacity of 1000 to 2000 lb. per heat, depending on the shape of the parts being nitrided. It was built for the specific purpose of hardening parts for electric refrigerators, which meant that production was to be regular and continuous, and relatively large in volume.

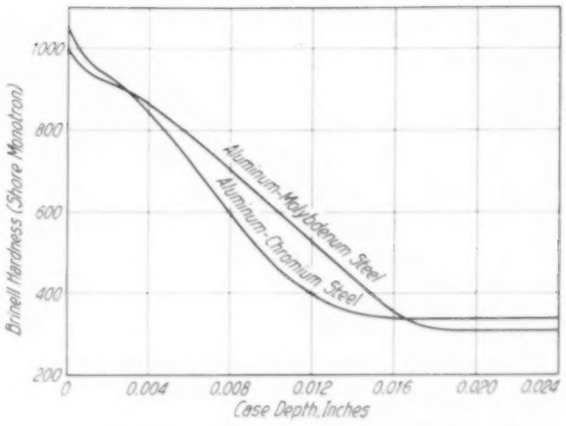
Continuous production on a large scale



Time-Temperature Curve of Pyrometer in Nitriding Chamber Carrying 1050 Lb. of Steel

indicated the need of continuous nitriding equipment, with its attendant economies, and therefore a study was made of the possibilities. Commercial nitriding units then available were either continuous or intermittent. The continuous type consisted of a furnace and two sealed containers which alternated in the furnace, the one nitriding while the other cooled and was unloaded and reloaded. Thus the furnace itself performed a series of cyclical operations. In the intermittent type the sealed containers were omitted, the furnace itself being sealed and forming the nitriding chamber, which necessarily cooled with each charge, with a consequent loss of time and loss of the heat stored in the furnace walls.

It would be difficult to adapt the above-mentioned continuous types to large-scale production, since the containers had to be filled,



Depth-Hardness Curves on Nitrided Articles. Hardness by Shore Monotron, 0.75 mm. diamond ball, penetration 0.015 mm.

sealed, and then loaded bodily into the furnace (which might be either box or pit type). Since such containers support the full weight of the charge, they had to be of increasingly massive construction as the charges became larger. Also the problem of sealing and the matter of loading and unloading became more difficult with larger sizes.

Bell Type Furnace Adopted

These considerations led the engineers at the East Springfield works to adopt the bell-type furnace. As can be seen from the cross-sectional drawing at the head of this article, the base (which corresponds to the cover of a pit-type furnace) not only supports the charge but also forms a part of the nitriding container, being a gas-tight shell, with its outer edges flanged down into an oil seal in a trough around its periphery. With such a construction the nitriding container then becomes merely a light metal hood, covering the charge and base; its lower edge also projects into the oil seal. The furnace bell, corresponding to the pit furnace itself, may then be lowered over the hood.

Other details of construction are shown in the drawing, including the recesses in the base refractories for some of the heating elements, the grid for supporting the charge, and the ammonia inlet and exhaust system. An operating unit consists of two such bases and hoods, and one furnace bell, continuously heated, which alternates between them.

Aside from the economy of continuously heating the furnace bell and thus conserving the heat stored in its walls (and this is a very considerable item), there are other advantages inherent in this type of construction: (*a*) Since the seal is outside the hot chamber, a troublesome mechanical problem is solved; (*b*) lightweight hoods are economical in first cost and maintenance; (*c*) loading and unloading is easier because the loading space is entirely open and stationary. Furthermore, since the bases are stationary, all ammonia lines come up from below and the outlets are permanently connected to the metal sheath; ammonia connections are made and broken as a part of the loading and unloading operations. All power and thermocouple connections are also carried in permanent conduit through the bases; electric circuits between either base and the furnace bell are effected by plug connections.

Views of the installation are shown in the halftones. One photograph shows the furnace shell in operating position on the base in the background, and the second hood on top of it, out of the way. In the foreground is the second base, loaded with approximately 1000 lb. of parts which have been properly racked in fixtures, and with the removable framework of ammonia exhaust pipes in position. Ammonia inlet pipes are concealed under the supporting grid. In the background against the windows are temperature control equipment and the ammonia supply tanks, regulating valves and absorption tanks.

To facilitate loading, the bases are set in a shallow pit, thus bringing the supporting grid just above floor level. Removable subway grating is laid around the base while it is being loaded.

A permanent subway grating walk is laid between the two bases and beneath it are located the incoming ammonia lines, the electrical

Load of Work, Properly Racked, With All Ammonia Lines Connected

conduit, an oil reservoir and a small electric oil pump. The latter two drain the oil seal troughs before the hood is removed at the end of a nitriding cycle; the oil trough is empty during unloading and reloading and is refilled after the hood is replaced. This prevents objectionable splashing and dripping when moving the hood on or off.

The photo alongside shows a workman in the act of lowering the hood into position over the assembled charge. Everything is now in readiness for the hot furnace bell, and the overhead crane moves it over as soon as it has finished in its other location.

Lowering the Hood Over the Charge

This Inverted Container for Nitrogen is Made of Thin Alloy Steel. Furnace shell in background will heat this hood

One of the curves shows temperatures during a typical nitriding cycle on a 1050-lb. charge in this furnace. Note that the hot bell is transferred after 29 hr. and the work cools rapidly under the thin alloy hood. The other curve shows the characteristics of the case obtained on two commercial alloy steels. The aluminum-molybdenum steel had the following analysis: 0.27% C, 0.60% Mn, 1.07% Al, 0.83% Mo, 0.21% Si. The aluminum-chromium steel contained 0.32% C, 0.45% Mn, 1.10% Al, 0.28% Mo, 0.13% Si, 1.36% Cr, and 0.28% Ni.

The furnace was built with some reserve capacity and present schedules do not keep it at maximum production. Even under these conditions, the following are the actual items of cost incurred per pound of steel hardened:

Ammonia, 0.1 lb.	1.40¢
Energy, 0.5 kw-hr.	0.80¢
Labor	0.43¢
Fixed Charges	2.58¢
Total	5.21¢

Labor cost includes loading, unloading, and attending the furnace and ammonia equipment. Fixed charges include interest on investment, depreciation and maintenance of furnace and its control equipment, hoods, ammonia equipment, and the electric traveling hoist. Depreciation is based on five-year obsolescence for the furnace and control and ammonia equipment; on a two-year life of the hoods; and ten-year useful life of the electric hoist.

It is estimated that when production schedules have increased to the point where the furnace is in full continuous operation five days and nights per week, the total unit cost of nitriding will fall below 1¢ per lb.

These figures are of interest as compared with unit costs ranging from 7¢ to 10¢ per lb. for hardening in present small commercial nitriding units. They are illustrative of the advantages inherent in large-scale operations, and indicate the possibility that, should nitriding grow to a volume commensurate with present-day carburizing, it may prove no more costly, perhaps even cheaper, than the latter.

SPECIFICATIONS FOR QUALITY METALS

HOW TO WRITE THEM

By F. M. Randlett
Pacific Coast Manager
Robert W. Hunt Co.
San Francisco

NO ONE can doubt that the standardization of machines, of processes, and of products of manufacture has been one of the prime aids to American technical progress. So many standards have been developed that certain critics believe they have extended even to the individual citizen. Without debating this point, we can agree with H. H. Morgan's article in METAL PROGRESS for January, that correct specifications for materials are a great help in buying and selling these raw materials and the semi-fabricated objects made from them.

Metals comprise one group of materials which have been studied extensively by purchaser and seller, and which, therefore, may be described accurately in a standard specification.

This use of the word "standard" naturally raises the question, "What is a standard specification?" Primarily, a standard specification is a specification adopted as standard by some party. At first, a specification may be a standard of one consumer or it may be that of the manufacturer (where a specialty is involved). When such a specification is found effective, its use naturally extends to other consumers as a result of the brotherhood of engineers. When it has spread this far, the association of consuming interests may advance the specification to a standard of that association.

By that time, the standard reaches recognition in trade from the manufacturing point of view. The material or equipment is used in other industries. The next stage is that represented in the activities of the American Society for Testing Materials and represents the collaboration of various consumers and producers in the standardization of material specifications. Beyond this, we have the final national classification of the American Standards Association.

Since the study of metals and alloys is a continuing study and the industries which use and fabricate them are advancing in technical excellence, it results that an increasing number of specifications is coming into use.

Even with the greatest possible use of existing standards, there will be many materials and equipment items on which readers of METAL PROGRESS must sooner or later commence to set

their individual standards, putting them in line for group use, association or society use, and eventually for use as a national standard. In the preparation of any such specifications, there are certain major matters that are worthy of mention. These were listed by the present writer in a recent address before the American Water Works Association as follows:

A specification for a product should contain the fewest possible restrictions consistent with obtaining the material desired.

The service which the product is to perform, in connection with reasonably feasible possibilities in its manufacture, should determine the limitations of a specification.

All parties whose interests are affected by a specification should be consulted during its preparation.

Excessively severe limitations in a specification are suicidal. They lead to constant demands for concessions, which must be made if the work is to be kept going, or to more or less successful efforts at evasion. Better a few moderate requirements rigidly enforced, than a mass of excessive limitations which are difficult of enforcement, and which lead to constant friction and sometimes to deception.

There is no real reason why a specification should not contain limitations derived from any source of knowledge. If the limitations shown by physical test are sufficient to define the necessary qualities of the material, and this test is simplest and most easily made, the specifications may reasonably be confined to this. If a chemical analysis or a microscopic examination, or a statement of the method of manufacture, or information from all four, or even other sources, are found useful or valuable in defining limitations, or in deciding upon the quality of products furnished, there is no legitimate reason why such information should not appear in the specifications. Neither the producer nor the consumer has a right to arrogate to himself the exclusive right to use information from any source.

Proprietary articles and commercial products made by the processes under the control of the manufacturer cannot, from the nature of the case, be made the subject of standard specifications, even though they may readily satisfy the requirements of an existing specification. The very idea of a specification involves the existence of a mass of common knowledge in regard to any product, which knowledge is more or less available to both producer and consumer. If the manufacturer or producer has opportunities which are not available to the consumer of knowing how the variation of certain constituents in his product will affect that product during manufacture, so also does the consumer, if he is philosophic and is a student, have opportunities not available to the producer of knowing how the same variation of constituents in the product will affect that product in service under special conditions with which he is familiar. It is only by the two working together and combining the special knowledge of each, that a really valuable specification can be made.

A complete workable specification should contain the information needed by all those who must necessarily use it in obtaining the product desired.

Where methods of testing, analysis, or inspection are well known and understood, it is sufficient if the specification simply refers to them. Where new or unusual tests are required, or where different well-known methods give different results, it is essential to embody, in the specification, sufficient description to prevent doubt or ambiguity.

All specifications in actual practical daily use need revision from time to time as new information is obtained, due to progress in knowledge, changes in methods of manufacture, and changes in the use of products. A new specification (that is, one for a product which has hitherto been bought on the reputation of the makers and without any examination as to quality) will be fortunate if it does not require revision within a year.

A complete workable specification for a product represents a very high order of work. It should combine within itself the harmonized antagonistic interests of both the producer and the consumer, it should have the fewest possible requirements consistent with securing a satisfactory product, should be so comprehensive as to leave no chance for ambiguity or doubt, and, above all, should provide for inspection and tests that will protect the consumer in his purchase.

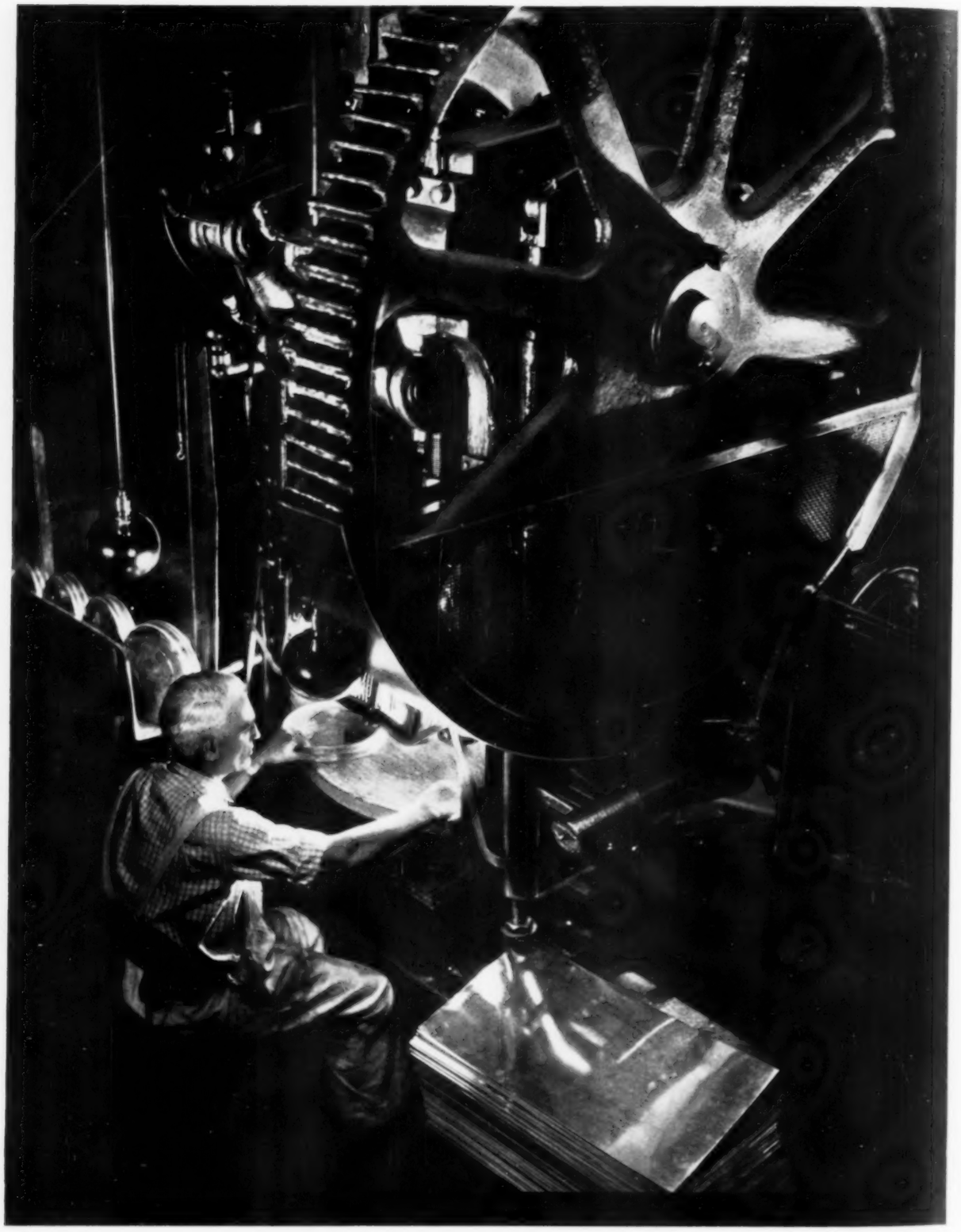
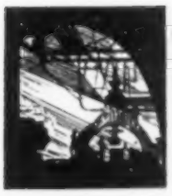


Photo by Eastman Kodak Co.

Movie Film Containers–
New Demands Met by Old Methods

EDITORIAL



THE highways and streets of the nation will be extra hazardous for the next few months, with the owners of the new Fords trying to beat everything else on the road, big or little. Not so good for the innocent passerby, who might be protected by about 100,000 extra speed cops. On second thought, that would not be such a bad plan for other reasons: It would employ a large number of idle men in a healthy, exciting pursuit; it would boost the sales of uniforms, brass badges and motorcycles; and it should pay its own way from fines for traffic law violations and leave a handsome surplus for the lean municipal and state budgets. On the other hand, the auto wreckers, hospitals and undertakers would, of course, lose some anticipated business.

A PRACTICE recently noted in the heat treatment department of a gear manufacturer is well worth repeating. While it is probably known to many, it will be new to some who read this.

This plant has a continuous normalizing furnace. Tray-loads of forged gear blanks are pushed in one end and come hot out the other. Uniform results are secured when the furnace is operating steadily, but it was noted that the first box-load of forgings accumulated when the furnace had been started after a shut-down would hardly be up to standard, and this first lot of gears, traced through to the end, lost a disproportionate number of rejects. Closer study revealed similar circumstances following the last part of a production run.

It was apparent, therefore, that the control devices with which the unit was equipped were incapable of increasing the heat from "no-load" to "full load" in the time it took to fill the furnace, or vice versa. This was the more serious since production in the machine department was never great enough to warrant keeping this furnace continually at heat.

Rather than rebuild the pyrometric control, which was undoubtedly adequate for normal operation, the metallurgist decided to use a pile of rejected forgings for a dummy charge. Several box-loads of these, sufficient to fill the furnace completely, are now stored at a convenient place. These are the first to go through the furnace Monday morning after it reaches heat. While this dummy load is being heated, the temperature of brickwork, hearth, and other portions of the normalizer becomes adjusted for the work that is to be performed on the steady stream of new forgings following immediately on its heels. Similarly, the end of the campaign is brought up by the same batch of scaly forgings. Therefore, the first as well as the last good gear blank comes out of the furnace while the latter is carrying a normal load of metal, and has just as good a chance of passing inspection as any piece in the middle of the shipment.

MANUFACTURERS of iron castings have frequently protested against the common habit of characterizing their product as "weak and brittle." Welders are equally restive when a welded joint is called "weak and brittle." Both can point to many instances where castings and welds have withstood vigorous sledging, and so there is some basis for a protest.

Unfortunately, they are the victims of circumstances which they cannot easily control. While it is possible to make tough castings and

tough welds, it is only too true that the most common varieties in the past have been more brittle than tough. Thus a bad reputation has been acquired, unwarranted by the present state of the arts. The engineer and designer and their teachers are a conservative lot, and expect the worst rather than the best, even though the best may be specified and is capable of being delivered.

Another reason why this condition changes but slowly is that statements of ancient date are embalmed in the handbooks and textbooks most frequently used. For instance, there are probably 100,000 copies of Kent (Mechanical Engineer's Pocket Book) 10 years old or older on book shelves in this country. A great majority of the responsible American engineers own and use these older editions, rather than the one rewritten in 1923 by some three dozen specialists. If they realized that much of the old book represents pre-War practice, they would scrap it as fast as they have replaced obsolete equipment.

Even the 1923 edition has this to say of cast iron: "The improvement in the manufacture of steel castings has limited the field of commercial employment of iron castings and malleable iron, but cast iron is still employed wherever weight or compressive strength is the controlling factor, and where as a structural part for a machine or building it does not have to withstand shock, tensile stress, or bending." Certainly the statement does not inspire respect for the material! Other paragraphs emphasize the influence of numberless conditions, such as composition, melting practice, molding practice, and size of section on the strength. So many qualifications, cautions and a lack of data on even the minimum properties to be expected are apt to reject cast iron from consideration when a new machine is being designed.

The above circumstances are being mitigated by the issuance of handbooks at short intervals by technical societies and interested corporations. The A.S.S.T. National Metals Handbook is one of these. We can also congratulate ourselves that its pages devoted to plain and alloy cast iron are understandable, accurate, and informative.

A third circumstance is probably of most importance. Cast iron lacks a vigorous ballyhoo. On the other hand, welding is adequately publicized, both in the advertising and reading pages of the technical and popular press; one is almost blind and deaf if he hasn't the feeling that great things are being done with welding, and old ideas about it must be discarded. Much may be said for the contention that the best and quickest way to rehabilitate iron castings would be to shout their virtues (for they have virtues) from the housetops, and keep on shouting. Undoubtedly users of competitive materials would then begin to suspect that they might do better with good cast iron.

LET the comment and correspondence in these columns since February on metallographical terms, such as sonim, solidus, and solvus, rest with the following quotation from "The King's English," a merry and wise book on diction (a dry subject) by H. W. and F. G. Fowler:

"The progress of arts and sciences gives occasion for the large majority of new words; for a new thing we must have a new name; hence, for instance, 'motor,' 'argon,' 'appendicitis.' The discoverers of argon are to be thanked for having also invented for it a name that is short, intelligible to those at least who know Greek, free of barbarism, and above all pronounceable. As to barbarism, it might indeed be desired that the man of science should always call in the man of Greek composition as godfather to his gas or his process. . . . With the strictly scientific words, writers and word users have not the power to decide whether they shall accept them or not; they must be content to take submissively what the men of science choose to give them, they being as much within their rights in naming what they have discovered or invented as an American founder in naming a new city. 'Minneapolis' and 'Pikeville' may have a barbaric sound, but there they are!"

PRODUCTION AND PROPERTIES OF SUPERIOR CAST IRON

By Oliver Smalley
Consulting Engineer
Pittsburgh, Pa.

FROM a strictly metallurgical standpoint ordinary gray cast iron lies between an unrefined and refined product. It differs from true iron-base alloys when in the molten state by possessing suspended graphite particles. This peculiarity is responsible for the low strength, mechanical weakness, and inconsistencies in service of castings which come from badly managed foundries.

During recent years there have been much study and discussion of the manufacture of improved cast irons and their properties. Much of this activity concerns additions of alloys such as nickel, chromium, or molybdenum. However, superior irons have been made commercially without the introduction of alloys by proper attention to such items as the physical constitution of the pig iron, superheating and refining during melting, and heat treatment of the resultant castings.

Almost every process has consciously or unconsciously attempted to control graphitization, whether steel scrap has been used in the mix, whether carbon and silicon have been reduced by special mixtures or melting conditions, whether hard iron has been graphitized by pouring in heated molds, or whether alloys or heat treatment have been involved.

Results of these different efforts to attain the same object are the superior cast irons produced today. However, commercial progress has not been proportional to the amount of scientific attention and research that have been applied. To some extent this is because the foundryman must retain the identity of what is commonly understood as "ordinary cast iron," together with some economic advantage over the steel maker. To hold and extend his field he must furnish castings that are consistently uniform and have a superior combination of physical properties without resorting to the costly processes and increased care necessary to manufacture any completely refined iron alloy, whether it be carbon steel or any other alloy casting, stamping, or forging.

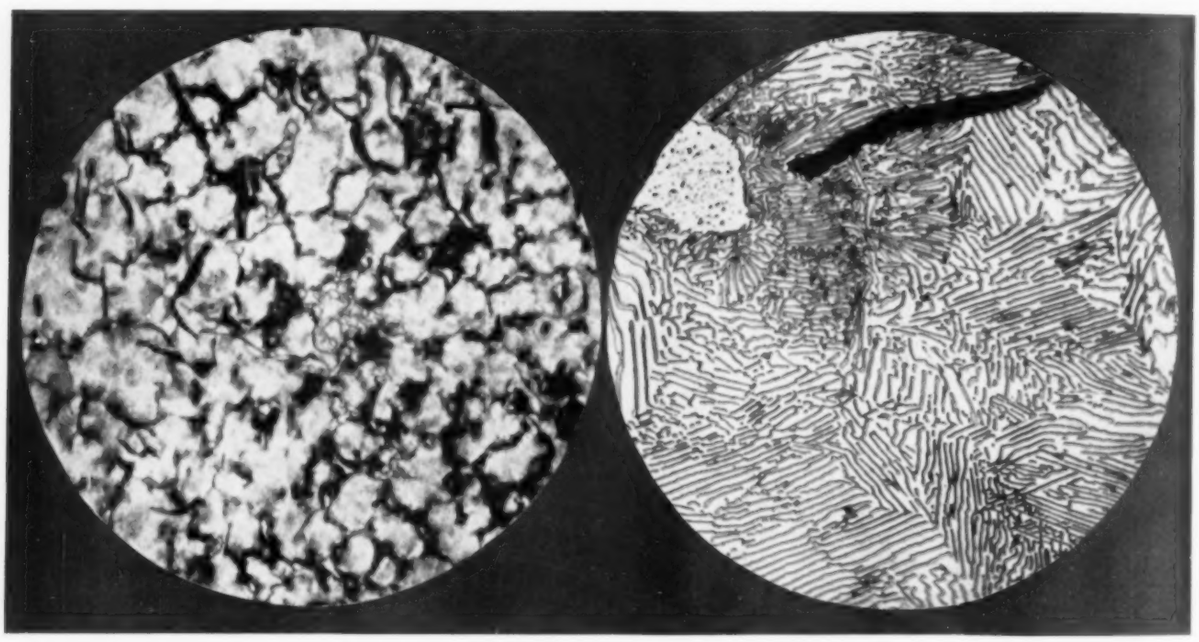
In what follows the writer will describe

one method whereby this can be done. The article will give most attention to the properties of the resulting castings, as befits the readers of METAL PROGRESS. It should be remarked, however, that these special irons known as "Meehanite" are a distinctly American development, the essential idea having been patented by G. F. Meehan about ten years ago. In these irons the graphite is controlled by adjusting the chemical composition (principally by melting much steel, if in a cupola) to a point where the casting would normally be white iron, and then causing all carbides over the amount necessary for pearlite to decompose into diffused particles of graphite (by the addition of measured amounts of calcium silicide to the ladle).

The same results can be attained whether the iron is made in the cupola, electric or air furnace. They require, in all cases, positive and accurate metallurgical supervision. It is then possible to control accurately not only the graphite content, but the *form* of the graphite as well. The photomicrographs show this; the high tensile pearlitic iron has the essential characteristics of a eutectoid steel. This structural feature explains its remarkable toughness as measured by the rotating fatigue test and the Charpy and Stanton impact tests.

In ordinary practice the chemical composition of the cast iron varies according to the requirements of the part to be made. Perhaps the most unique characteristic of castings made by the Meehanite process is that the silicon content need not be held within the strict limits necessary for semi-steels and alloy cast irons. Another attractive feature is that the foundryman may adjust each ladle of molten iron as it comes from the furnace so as to meet any given set of conditions in the castings to be poured, such as mass influence, strength, hardness, and machinability. It also has the advantage of Brinell hardness figures up to 275, still retaining good machinability.

Two Photomicrographs of Meehanite



Structure of Meehanite at Low and High Power. Unetched view at 100 diameters shows uniform distribution of thin graphite flakes. Etched metal at 2000 diameters shows a matrix like eutectoid steel

Designers' Attitude Toward Cast Iron

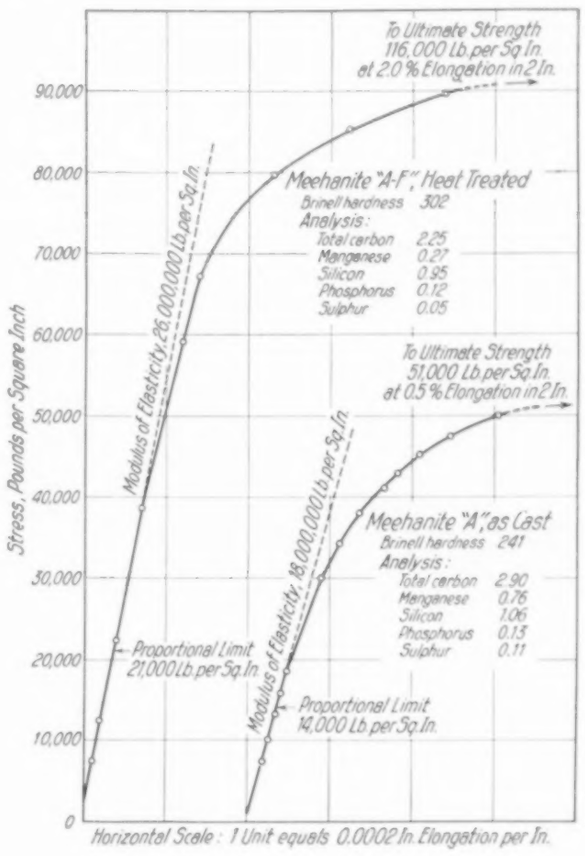
It is regrettable that most of the physical testing of gray cast iron has been done without due regard to the metallurgy of this material or on metal that was not meant to be anything but free cutting or ornamental cast iron. Most

engineering textbooks therefore describe cast iron as a material that has no straight-line relation between stress and strain — in other words, it does not possess "true elastic properties." It is also reiterated that it is a brittle material.

It is unfortunate that all gray cast irons should be so branded, for modern irons are made that have true elastic properties and are not brittle. However, the impression is widespread that cast iron is something that is used according to the dictates of experience, and is not susceptible to accurate design (as a steel structure, for instance, would be).

This attitude toward gray cast iron is not altogether the engineer's fault. Metallurgists and foundrymen have probably never appreciated fully his point of view. For example, tensile tests giving accurate measures of elastic constants are difficult to make and require special equipment; the transverse test is used, principally because it can be made cheaply. In this test, loads and corresponding deflections are measured and substituted in the beam formula to obtain values of the modulus. Such results mean little. For instance, Adamson and Bell tested 1x1-in. common gray iron test bars on 36-in., 18-in., and 12-in. span (Carnegie Scholarship Memoirs, 1927). When the beam span is 36 in. the modulus of elasticity computed from the deflection at fracture may be 11,500,000 lb. per sq.in.; for the same size of test bar cast from the same ladle and tested on a 12-in. span, the modulus figures to 6,400,000 lb. per sq.in. No matter how this may be explained, the result is that the engineer has no true value for Young's modulus and this is one of his most important constants. If he uses steel, then very little error arises by using 30,000,000 lb. per sq.in. because steel gives that average value.

Stress-Strain Curves of High Strength Cast Iron



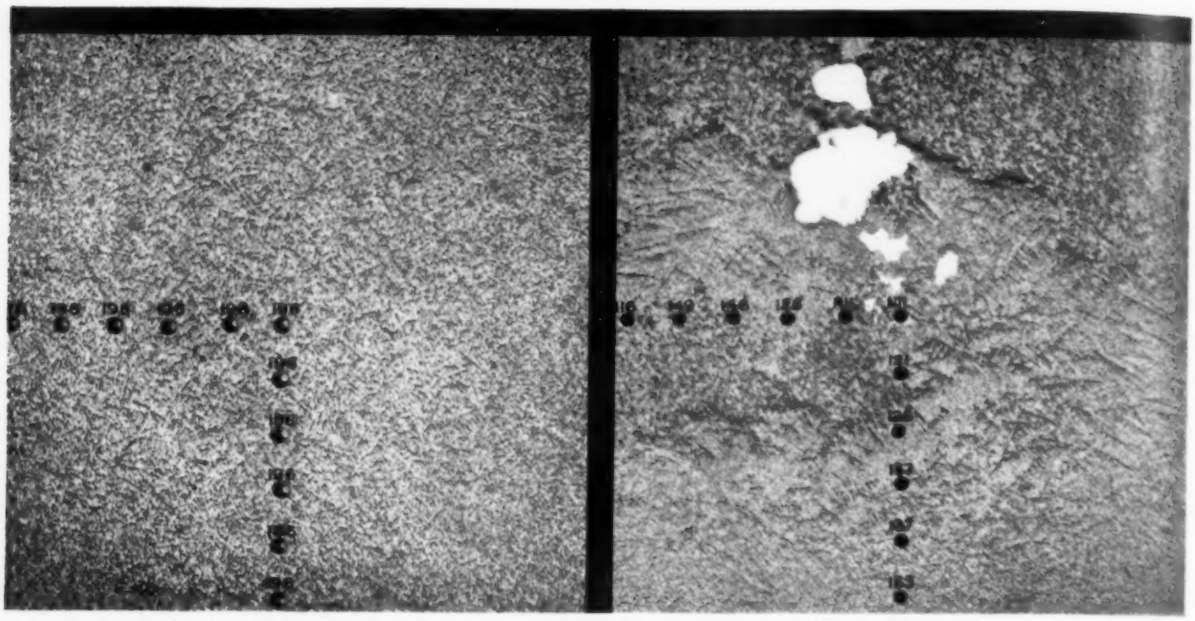
Whether common gray cast iron has or has not a linear stress-strain curve (and most of the authorities agree that it has not) two diagrams are presented herewith which show correctly made elastic limit curves of two varieties of Meehanite, one heat treated. These do give a straight-line relationship between the stress and strain in a standard tension test piece; the true elastic limit of the metal as cast being 14,000 lb. per sq.in., and of the heat treated sample 21,000 lb. per. sq.in. The modulus of elasticity is 18,000,000 and 26,000,000 lb. per sq.in. respectively. In other words, here is gray cast iron that conforms to the concept of true elasticity.

Now for the question of brittleness. A photomicrograph magnified 50 times, taken from a casting of

COMPARATIVE PHYSICAL PROPERTIES OF COMMON CASTINGS

Materials	Tensile Strength Lb. per Sq. In.	Modulus of Elasticity Lb. per Sq. In.	Endurance Limit Lb. per Sq. In.	Brinell Hardness
Gray cast iron	26,000	6,000,000 to 11,000,000	12,000	150
Malleable iron	54,000	25,000,000	25,000	115
Annealed carbon steel casting	60,000	29,000,000	27,000	130
10% aluminum bronze	60,000	–	25,000	120
13% silicon-aluminum alloy, modified	24,000	10,000,000	6,000	50
Pearlitic cast iron				
Meehanite "A", as cast	52,000	20,000,000	21,000	227
Meehanite "A-F", heat treated	110,000	26,000,000	28,000	270
Electric weld metal, machine-made with low carbon wire	50,000	29,000,000	12,000	–
Mild steel forging	70,000	30,000,000	33,000	140

High Tensile Cast Iron **Soft Gray Iron**

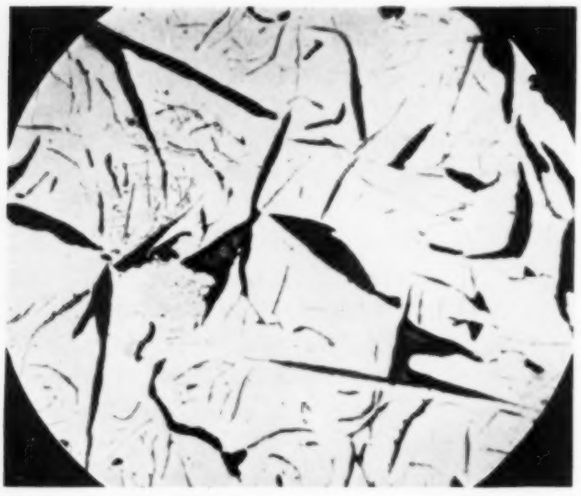


Macrographs of Six-Inch Cubes Sectioned Through Center

Hardness uniform, free from spongy areas or open cavities

Hardness varies with segregation. Characteristic open cavities

3-in. section made of ordinary gray iron such as was used in the transverse tests referred to, is shown below. Compare this with the structure of the pearlitic iron on page 50. It is not difficult to imagine the different effects of these two forms of graphite on the ductility or toughness of the two cast irons. It is also easy to see that intermediate structures will give different degrees of ductility.



Unetched Section of Gray Cast Iron at the Center of 3-In. Bar (50 Diameters)

The designing engineer would like to know more about this property of toughness or ductility. Unfortunately, he really does not know where ductility ends and brittleness begins in either cast iron or steel! Also it is a rare occurrence for metals to fail under static loading; fatigue is the cause of most engineering failures. Even ductile metals like copper and mild steel finally snap off short if stressed repeatedly beyond their endurance limit because a crack has been produced and is propagated until the cross-section is cut down to the danger point. Numerous measurements of these endurance limits have been conducted since Wöhler first studied the matter in 1852, and it appears that the fatigue or endurance limit is a fundamental property of the metal in question.

When the stresses imposed on a structure are static in nature, the tensile or compression test values are sufficient for its design. When the loads continually change, setting up stress fluctuations, a material fails under stresses below the static test. The table on page 51 shows that properly cast and heat treated irons (Meehanite) have endurance limits which compare favorably with the best varieties of cast metal and even with mild steel forgings. It

should be noted that the fatigue strength of the commonest cupola Meehanite is greater than high class electric arc welds, made with automatic machinery, and is probably more than twice as good as weld metal from bare electrodes.

Other significant characteristics of this series of high strength irons that establish them as improved materials for engineering construction are as follows:

Brinell hardness, as cast	160 to 280 as required
Brinell hardness, heat treated	280 to 600
Compressive strength	140,000 lb. per sq. in.
Transverse strength, up to	6,000 lb.
Torsion, 0.5-in. round bar, 10 in. long	
Fiber stress	45,000 lb. per sq. in.
Total twist	31°
Charpy impact	7 ft-lb.
Stanton impact	2700 blows
Specific gravity	7.49

Tensile strength at elevated temperatures is shown on the curve, top next page, and indicates no marked drop until 900° F. is passed. These test pieces were pulled at the ordinary rate of extension.

Since many cast irons are used under fluctuating temperatures, the ability to retain shape and to resist corrosion is important. Because the form of graphite in cupola-melted Meehanite "A" is such that continuity and interlocking are avoided, it does not grow in size at the highest superheated steam temperatures. Where heats are encountered up to 1100° F., an iron known as Process "M," so designed that the graphite is in nodular form and the carbides stable up to that temperature, is recommended. When 1100° F. is exceeded, resistance to scaling becomes equally important, and Meehanite Process "H.R." is designed to meet this requirement up to at least 1700° F.

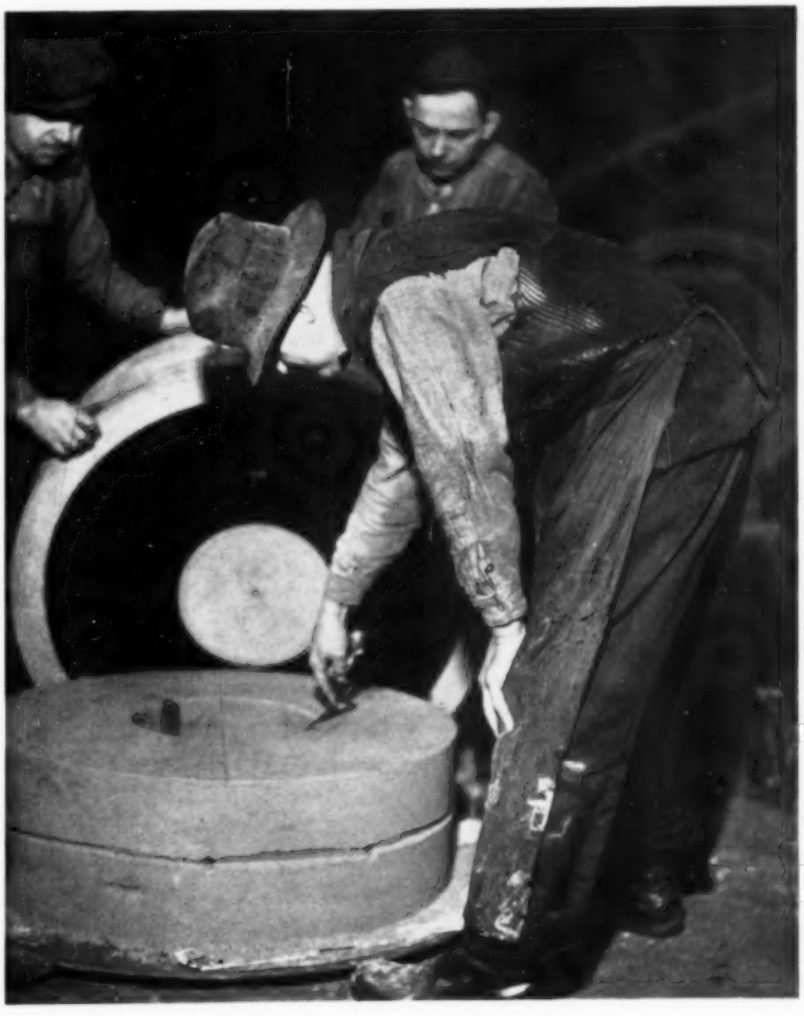
Mass influence was the subject of a recent discussion by the American Society for Testing Materials. Various foundries were invited to submit test bars 0.75, 1.25, 2, and 3 in. diameter, and from these tensile test bars were machined and pulled. Representative results in pounds per square inch are given below:

Diameter	Iron B	Iron C
0.75 in.	27,200	37,500
1.2 in.	25,400	35,900
2 in.	18,800	27,450
3 in.	14,380	22,700

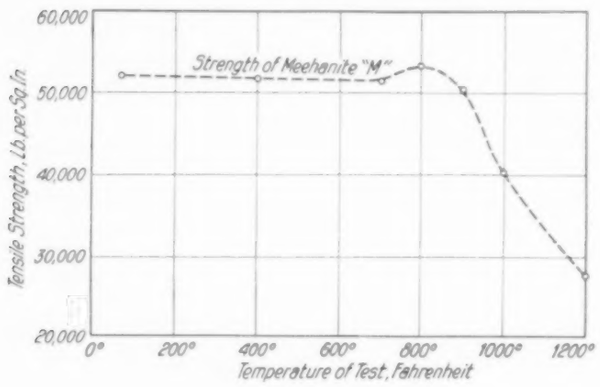
Similar tests were made from Meehanite "A" in bars up to 6 in. with these results:

Size of Original Bars	Tensile Strength lb. per sq.in.
1.2 in.	51,700
2 in.	53,300
3 in.	52,400
4 in.	50,050
6 in.	47,450

Photo by Henry M. Mayer



Pearlitic Iron Retains Its Strength up to 900° F.



These results are obtained by adjusting the "carbide balance," proportional to the mass to be cast, by the metallurgical means indicated at the beginning of this article.

The relative effect of mass on the solidity and structure of high tensile pearlitic iron and common gray iron is portrayed by the accompanying macrographs. These are reduced about half size and show how castings of heavy sections (6-in. cubes) may be made without planes of weakness or spongy regions. Because of this uniformity, the strength of any machine element made of the pearlitic cast irons under discussion is directly proportional to its cross-sectional area. In other words, the designer is assured that here is a dependable material; every square inch of cross-section will carry its full share of operating load.

This is especially valuable in the design of pressure castings. Medium grain cast irons will generally serve for hydraulic castings up to 300 lb. per sq.in. test pressure, if they are not accompanied by casting defects such as shrinks, blow holes and sponginess. When the castings are to withstand temperature and gases, coarse and medium grained irons are unsatisfactory even for low pressures. As the pressure increases, fine grain and uniform density become more essential. If castings are to withstand the kerosene pressure test the slightest defect will be revealed.

Uniform grained metal such as shown in the macro on page 52 has been used with great success in valves for high pressure gas lines and high pressure gasoline lines. These valves are tested with air and kerosene; test pressures run as high as 3750 lb. on sections up to 2 or 2½ in. High pressure gas meters and regulators are other examples. Regulator bodies are in daily production that pass 6000 lb. per sq.in. hydrostatic pressure. Meter bodies whose outer section approximates 1 in. thick, but which are divided into two parts by a light diaphragm only ⅜ in. thick, are subjected to a test pressure of 1250 lb. per sq.in.

Possibilities of Heat Treatment

Presence of coarse flakes of graphite and the instability of the carbide in ordinary soft gray irons are responsible for the difficulties and uncertain results obtained by heat treatment or annealing, whether the desired object be to obtain greater strength, hardness, ductility, or machinability.

As has been shown by the microscope, pearlitic iron compares with carbon tool steel, the essential difference between the two being the presence of graphite in varying controlled amounts. Like ordinary tool steel, these Meehanite "A" castings may be hardened by rapid cooling from above the critical change point, or softened by prolonged heating at or about the Ar point. These changes in hardness obviously affect the physical properties in much the same way as they affect the ordinary 0.9% carbon steel.

The technique of the manufacture of castings responsive to heat treatment is important. The control of the graphitization by calcium silicide additions must be done with considerable accuracy and to such a degree that heating for the purpose of hardening does not decompose any of the hardening carbide. This is a common trouble in the heat treatment of ordinary cast iron.

Meehanite castings, annealed, quenched in oil, or quenched in water are finding extensive use in railroad roller bearing axle boxes, gears, dies of all varieties, cylinder and pump liners, conveyor machinery, shovel and dredge parts.

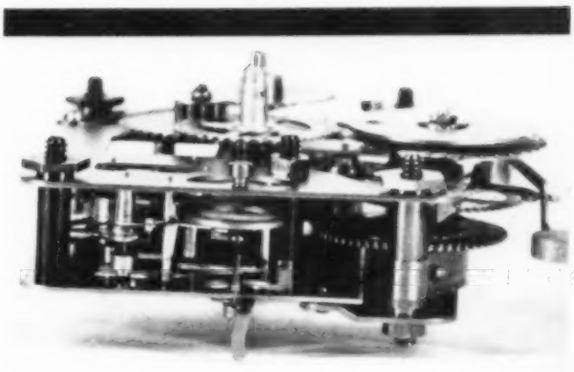
In conclusion, it is to be hoped that this description of a variety of high test, heat treatable cast irons which is in daily production on a tonnage basis will convince its readers that the product of the iron foundry may be made to conform to the most rigid engineering requirements.

HARDENING A CLOCK'S BALANCE STAFF

DEVELOPMENT OF PRESENT PRACTICE

By J. A. Reinhardt
Chief Engineer
Western Clock Co.
La Salle, Ill.

Modern Alarm Clock Movement



HOROLOGY, the art of making timepieces, with its written records dating centuries back and the ancient mechanisms still extant, joins in one legible history the development of many arts and sciences — astronomy, mechanics, mechanism, metallurgy, and the cutting and shaping of metals. It therefore is a fascinating subject. For no single element of the modern watch or clock is this statement more true than for the balance assembly, really the essence of the mechanism. This assembly includes the balance wheel and hairspring and their supporting balance staff.

Transition from the methods of the handworker, who made our grandfather's clock, to the machinery of mass production, which manufactures the bedside alarm clock, has presented some interesting problems, especially in the preparation and heat treatment of the balance staff. These changes have not been accompanied by changes in form and function, for these have remained practically the same. The balance staff has always had to carry some bar or wheel vibrating in its bearings, 24 hr. per day, through many months and years. These rubbing surfaces have presented the greatest problem of wear, for the other parts move comparatively slowly.

One of the earliest balance staffs on record is part of the Foliot escapement which used a vertical bar for the vibrating member. In this mechanism, which was used at the end of the thirteenth century, the severe wear was alleviated by suspending the staff from a cord. As shown in the sketch on the next page, the lower bearing was only a guide, but was subjected to pressure from the action of the escape wheel.

Inasmuch as all the parts were made of iron during this period, constant faithful attention must have been required to keep the bearings in running order. That the early mechanisms received such care is evidenced by the fact that a tower clock in the Glastonbury Abbey ran with a Foliot escapement for almost five centuries.

All clock movements before 1500 were driven by weights. The invention of the mainspring by an unknown inventor made the watch possible; its early form (used as late as the eighteenth century) consisted in a hammer-hardened iron ribbon carefully filed and polished. Corrosion probably caused the substitution of brass ribbons hardened in the same manner; at any rate many of the old clocks were powered by brass mainsprings. The early nineteenth century clock repairer used a hammering device for rehardening those which became too weak in service.

In 1504, the first watch, or rather "watch clock," was built by Peter Heinlein in Nuremberg. The word *built* is used advisedly, for the watch was 6 in. diameter. About the same time English clock makers became interested, and developed their own type of clock watches. In a watch one end of the Foliot escapement could not be hung by a cord; a second bearing capable of sustaining some weight became necessary.

Watch makers made quite an ado about this second bearing. They called it the "balance cock" and often embellished it with elaborate engravings. Increased resistance to wear was obtained in the sixteenth century by using brass or silver for the cock, and carburized steel for the balance staff.

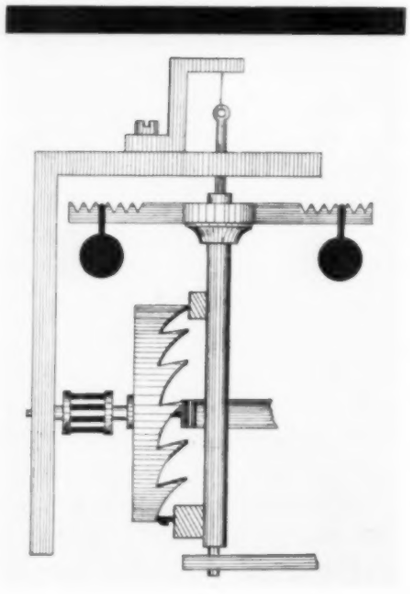
First use of Galileo's pendulum in 1657 by Huygens, a Dutch mathematician and horologist, eliminated the balance staff from clocks until many years later when the watch escapement was applied to small table clocks. Huygens also introduced the principle of the pendulum into watches in 1665 by means of a stiff pig bristle. This bristle, when fastened at one end, had a motion which, in connection with a free swinging balance wheel, approximated the isochronism of the pendulum. The pig bristle was soon supplanted by a straight steel spring, and this in time by the coiled hairspring as we know it today. With the advent of the pendulum and the hairspring the Foliot escapement was abandoned.

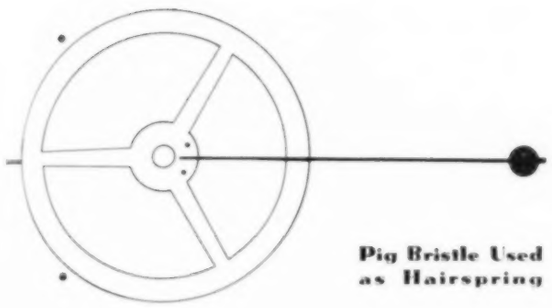
Early Balance Cock

Substitution of non-ferrous metals for iron spread further, and early in the seventeenth century, watches were built with silver pivot plates and silver cases. Shortly thereafter the plates of all clocks were made of brass. This material only was used for bearings until 1704 when Nicholas Facio, a Swiss artisan, introduced the first drilled jewels as bearings in fine watches and chronometers. In lower priced movements, the pivots still run in brass and nickel silver bearings.

The balance staff and its bearing must have been a thorn in the side of the early manufacturer of low-priced clocks. The orthodox balance assembly with sleeve bearings developed far too much friction, and the jeweled bearings cost too much. The problem was brilliantly solved by an unknown American artisan in the early part of the nineteenth century. He pointed each end of the staff and let these points ride in the countersinks of two hardened screws. Thus, by carrying the weight of the balance on point contacts, he obtained a minimum of friction, less, in fact, than that which was developed in the jeweled cap bearings of high grade movements. This combination has withstood the test of time and is used today in all alarm clocks on the market.

First Form of Balance Staff





Pig Bristle Used as Hairspring

So much for the development of the form. Now for the material.

Early attempts to carburize the balance staffs made of wrought iron were no doubt attended with many failures due to distortion and oxidation. Bits of bone, horn, leather, and dried blood were added to the powdered charcoal to improve conditions. That the idea was soon abandoned is indicated in the instructions given to the young apprentice 200 years ago.

He was coached in the fine points of welding together a number of wrought iron plates which had been carburized to the core. The resultant large section was alternately hammered and annealed through many reductions until he obtained a fine-grained, comparatively homogeneous material which he could machine and harden with a fair degree of success. This product is the cemented steel of history.

Watch Makers Were Wire Drawers

To make balance staffs it was necessary for him to forge this steel into a rod which was subsequently cleaned up and filed to his best approximation of a round section. He then pointed the rod and drew it cold through various holes in a draw plate.

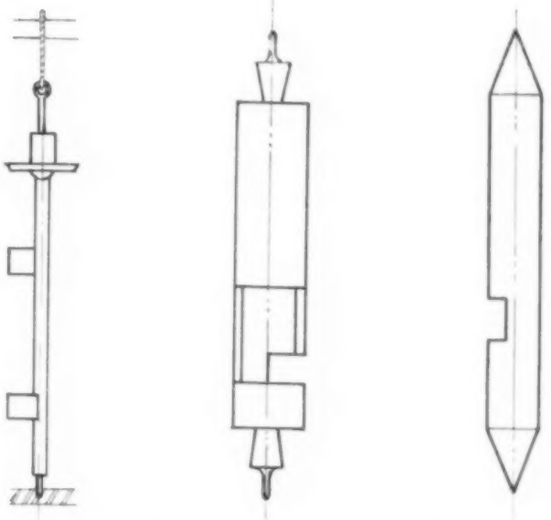
This draw plate was one of the most important pieces in the clock maker's equipment. Each man prepared his own, and the apprentice spent many weary hours in learning to form and peen the various holes so that his pivot and staff rods could receive the proper reduction between anneals.

In the year 1740, Benjamin Huntsman, an English clock and watch maker, conceived an idea which revolutionized the fine steel industry and simplified the problem of the hardened balance staff, and the cemented steel spring. He melted carburized wrought iron in a clay crucible and produced the first cast steel. The process still exists, substantially unchanged, and the product is now known as crucible steel. Both the cutting quality and hardening power of rods made from this new steel showed a distinct improvement; uniformity was also secured. The clock maker could now be sure of accurate, smooth balance staffs and that a fair percentage of them would come out of the hardening process in usable form.

A century and a half later, one still finds the great French horologist, Claudius Saunier, suspicious of commercial steel, and advising that steel must be refined through alternate anneals and reductions by hammering. He says, (in the "Hand Book," English edition, 1888, by Tripplin and Regg), "Steel thus prepared has more body; the particles comprising it are more closely pressed together, it files and turns well, can be heated more evenly, and is not distorted or only very slightly in hardening, *provided the requisite precautions are taken.*"

Among these precautions he advises Covillot's method: "Take some young garlic, the younger the better, mix it with sufficient good walnut oil to cover the garlic and form into a paste; then place it in an earthenware pot on the fire." When this mixture begins to boil the steel to be refined is heated to dull redness and quenched in the paste. The operation is repeated a number of times and the black crust

At left, Foliot's verge escapement; at center, cylinder escapement; right, modern dead beat type



Development of the Balance Staff

which forms on the steel is not removed. After the last heating, the steel is cooled very slowly, and then, as a final "precaution" it is set to "cook for 10 or 12 hr. in the composition of garlic and nut oil" over a spirit flame.

These hardening methods of 10 years ago seemed to have changed but little since the first artisan prepared his own cemented steel. It is true that in quenching the staff the clock maker did not plunge it into the back of a well-fattened slave, as did the sword makers, but he still plunged the red hot staff into the vitals of a young and juicy onion!

The various heating methods and quenching media developed through the years of clock fabrication make interesting reading. Saunier comments on the subject: "A workman frequently pretends that he has some exceptionally good solution for hardening of which a great mystery is often made; but it is very generally admitted by those who are well informed that these so-called secrets are a delusion and in no sense superior to pure water." He then naively retreats from this position with, "There is a certain amount of truth on both sides and the former class are somewhat justified by the experiments with the various solutions enumerated below." Thereupon he proceeds to recommend many of the following methods:

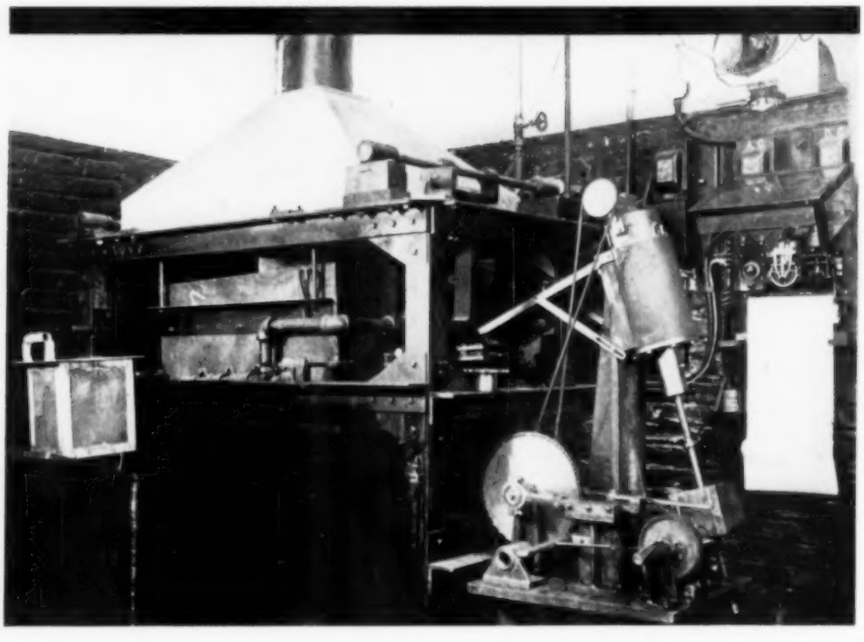
For heating, a single staff may be laid between two pieces of charcoal and heated with a spirit flame and blowpipe. Another method is to surround completely a single staff with a paste composed of prussiate of potash, lard, castile soap, and beeswax. He recommended that a single staff should be rapidly dipped at a dull red heat into a paste composed of 30 parts of fish oil, 10 parts of tallow, 4 parts of violin bow resin, 2 parts of wood charcoal, 2 parts of bone charcoal, 6 parts of tartaric acid, 2 parts of potash, 4 parts of ammonium carbonate, 5 parts of potassium cyanide, and 4 parts of potassium chromate. More modern methods are represented by the suggestion that a number of staffs could be placed in a covered box surrounded by either charcoal or steel turnings, heated in a furnace, and the entire contents dumped into a quenching medium.

Quenching media to give tough steel contain some materials which are novel to moderns, such as resin, sealing wax, bread crumbs, and vaseline. Other suggestions which appeal more reasonably to us are warm water, 1% soap solution, and mineral oil.

Quenching liquids for producing hard balance staffs included cold water. French authorities wanted water which had been used repeatedly, whereas Germans would use only fresh spring water. Various salt and acid solutions were also recommended, some fairly complex, such as: Sea salt 5 parts, sal ammoniac 1 part, water 20 parts. Another was sulphuric acid 4 parts, nitric acid 1 part, pyroligneous acid 1 part, and water 1000 parts, with the recommendation that it be used very cold for best results.

For the production of glass hard staffs,

Furnace Used to Harden Balance Staffs



mercury, nitric acid, opium, or any cyanide solution was recommended.

For drawing these balance staffs Saunier mentions that the polished staff may be rolled around on a hot stove to the desired color or heated in a layer of metal filings. Baths of molten metals, such as tin, bismuth, cadmium, lead, and lead-tin alloys, are mentioned. Another method, known as blazing-off, consisted of heating the staff dipped in various oils until the oil burned off; the variety of oil determined the temper.

While these old methods now seem fantastic, yet they could accomplish the desired result in the hands of an artisan trained in a difficult school. Before proceeding to the modern methods of heat treatment and preparation, a word of tribute must be given to the manual skill of the early artisan. Practically every student is struck by the very smooth action of the iron clock movements. The lathes and dividing engines seem very crude; nevertheless the gears mesh with precision and ease.

In spite of the special steels and alloys and the accurate production machinery now available, the modern alarm clock balance assembly is not expected to run through the centuries. However, many inexpensive movements have run 20 years regardless of spirited changes in style which forms one of the major problems in manufacturing today. The careful control of conditions which has developed during the last generation should increase this percentage considerably.

The care with which such control is exercised is well illustrated by the following specifications and testing methods we impose on balance staff wire:

Chemical analysis: Carbon, 0.95 to 1.05%; manganese, less than 0.30%; sulphur, less than 0.025%; phosphorus, less than 0.025%.

Allowable limits in diameter: 0.0845 to 0.0855 in. Allowable out of round: 0.0005 in.

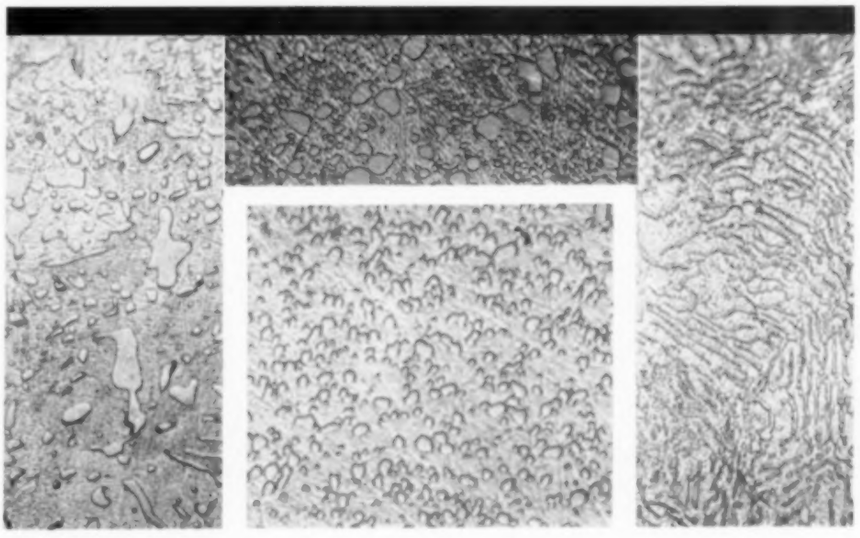
Temper: Stock as it comes from the last draw must have a Rockwell hardness of 95 to 102 (using B scale, 100-kg. load, and $\frac{1}{16}$-in. ball penetrator), test being made on the original round wire in a V-block.

General: Body of metal must be entirely free from pipe. It must have a uniform fine grain so that it will harden properly when quenched in oil. Surface must be free from die marks and slivers, but not brightly polished.

Since the hardening process is based on a uniformly fine structure of globular cementite, the wire is not accepted unless it conforms to samples with which each supplier is provided. Photomicrographs show the correct structure and structure of undesirable material.

When a shipment is received, short samples are cut from both ends of each coil. These samples are hardened with regular production lots and brought to the laboratory for examination as to hardness, grain structure as revealed by fracture, and surface decarburization. Rockwell hardness, C scale, diamond penetrator and 150-kg. load, must then lie between 60 and 62 on the original round. About 10% of the

Good and Bad Microstructure of Balance Staffs



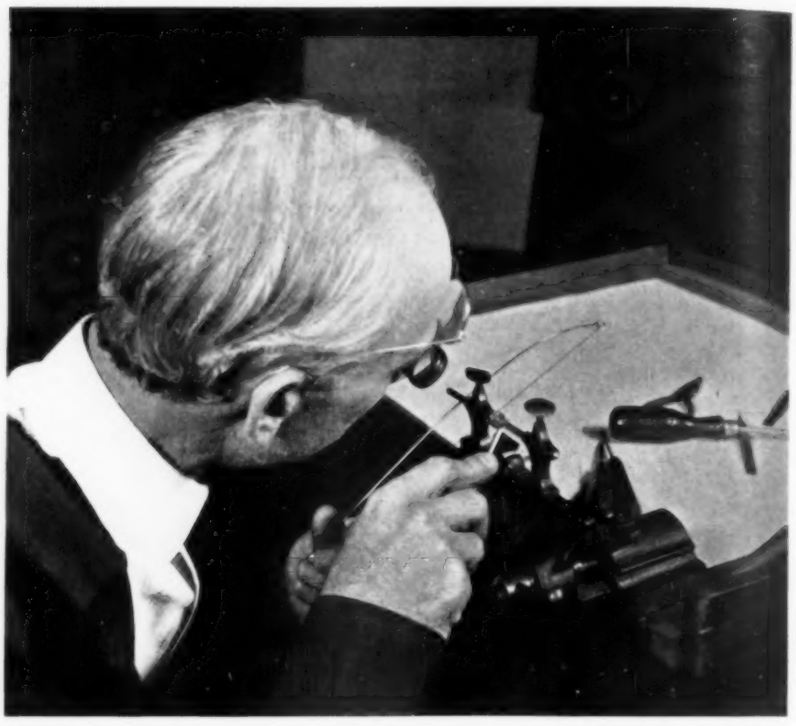
Photomicrograph in Lower Center Represents the Most Satisfactory Material, Finely Divided Globular Cementite. The other micros are of unsuitable structures

samples are examined under the microscope. A composite sample from all coils is analyzed chemically.

While the foregoing test routine is not infallible, since its inception no defective balance staffs have been found in the finished state which are traceable to defects in the wire.

Fabrication processes are particularly interesting when compared to the methods of 1890. The hardening operation has been freed as far as possible from the influence of the human element. However, the foreman in charge checks the grain and fracture of a small percentage from each lot by cracking off the sharp point as well as breaking the body of the staff.

An Old-Fashioned Precision Tool



The Bow Lathe Was Once an Important Tool of Watch Makers. W. H. Samelius, director of Elgin Watch Makers' College, is shown using one

The furnace is a commercial type built by the American Gas Furnace Co. The slightly inclined nichrome hearth is given a gentle bump at 15-sec. intervals which slides the staffs forward in the corrugations. The automatic feeding device is of local design. The furnace is fired with 560-B.t.u. gas fed through an automatic mixing valve activated by a Minneapolis Honeywell motor. One of the eight burners is placed on a separate valve without air connection and is used to control the furnace atmosphere. Leeds & Northrup recording controller holds the temperature within a few degrees of 1425 F.

As the staffs fall off the end of the shaker hearth, they drop through a tube into a tank of Houghton's No. 2 soluble quenching oil. The tube extends far enough into the oil to form an atmospheric seal, and the parts settle into a brass wire basket. Natural circulation of oil in the tank is sufficient to hold the proper temperature, which is 100 to 110 F. The temper of these staffs is not drawn.

After being hardened, the staffs are ground to correct form. A final check for temper is made in the laboratory at this stage. The Rockwell tester is again brought into play both on the points and on the body of about 1% of the production. The diamond penetrator is used on the round as before, but in addition a small number of staffs is tested by placing them one by one in a vertical socket so that the pointed end is used as a penetrator in a block of standard hardness.

Very extensive tests prove that such carbon steel staffs wear longer than the various chromium and molybdenum steels which were placed under investigation.

After the final test is finished, the staffs are given their last point dressing and polish. Polishing operations used in the industry vary a great deal. German practice uses both tumbling and burnishing by means of the needle sack (which was described in the article on needles which appeared in January, 1931, METAL PROGRESS). American practice generally consists in a hand stoning operation for the elimination of broken and battered points, followed by wet tumbling to blunt slightly the needle-like end.

BISMUTH, ESSENTIAL TO FUSIBLE ALLOYS, HAS ADDITIONAL POSSIBILITIES

By Walter C. Smith
Metallurgist
Cerro de Pasco Copper Corp.
New York

Iridescent Crystals in Ladle Skull

EVEN though nearly all of the chemical elements are metals, the ones in common use may be counted on the fingers. Of course, this is only a reflection of the fact that chemical science, which has discovered the existence of these metals, is so young a science that industry has not yet had time to utilize its discoveries. It is also a sure indication that many of the metals now used but rarely will have increasing importance as technicians and engineers become more familiar with their properties and as scientific metallurgists study their alloys more intently.

Bismuth is one of these comparatively neglected metals. It was probably produced as early as the thirteenth century, but the metal was so impure that it was confused with the more common lead or zinc, or with antimony, which it resembles in chemical properties. It remained for the chemists of the eighteenth century to identify bismuth as a distinct element in the pure state.

Bismuth occurs in the earth's crust in approximately the same quantity as silver and tungsten. Some ores contain native bismuth but the sulphide and oxide ores are the more important, and until a few years ago were the principal sources of the metal. Many lead ores and copper ores and some tin ores contain bis-

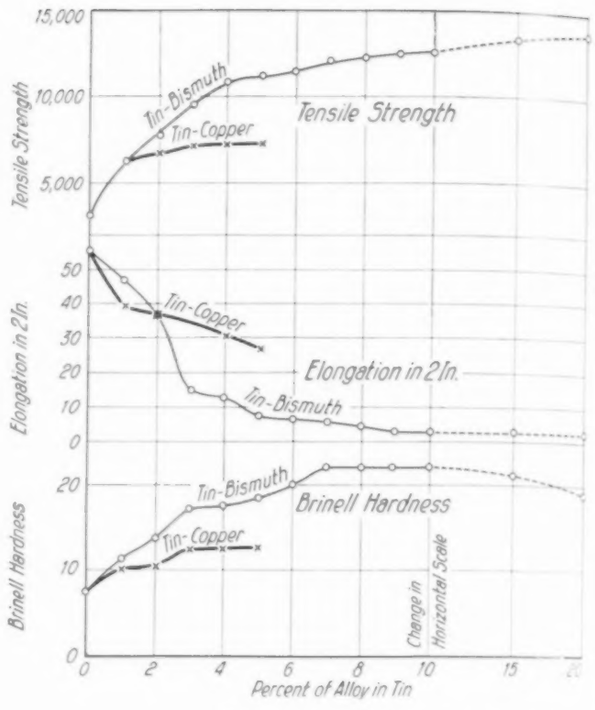
muth in small amounts. During the refining of lead and copper this bismuth is concentrated in residues and recovered with the gold and silver, from which it is easily separated. This by-product bismuth now supplies the major part of the world's demand. Consequently, present supplies are adequate for the uses to which it has so far been put.

Bismuth is classed by chemists with arsenic and antimony as a subgroup of the fifth group of the periodic table. It is a coarsely crystalline, brittle metal, having a brilliant luster and a silver-white color with a distinct pink tinge. Its atomic weight is high: 209. In the solid state it has a specific gravity of 9.8, midway between iron and lead. The specific gravity in the liquid state at 275° C. is 10.067, and it has the unusual property of expanding 3.3% in volume when freezing. Its melting point is 520° F., considerably higher than tin (449° F.) but lower than cadmium (610° F.) and lead (621° F.).

Solid bismuth has a very low thermal and electrical conductivity (probably the lowest values of all the common metals) and its electrical resistivity is affected by magnetic fields, by pressure, and by X-rays. It is also the most diamagnetic — that is, most repelled by magnets — of all the metals. It also has unusually high thermoelectric value. It offers approximately the same resistance to the passage of the short rays as lead.

Such unique properties, either singly or in combination, are responsible for the best-known industrial uses of the metal, to be described later. At the present time approximately 75% of the bismuth consumed is utilized in the manufacture of astringents and antiseptic powders containing the subnitrate. Pharmaceutical grade bismuth must meet very rigid specification as to analysis, and is, in fact, one of the purest metals marketed, being of the same order as fine gold, or silver, and the highest grade of electrolytic zinc.

Bismuth can be electroplated readily to give smooth surfaces. The deposit can be polished to a very brilliant finish, or heat treated for the production of colors. Bismuth-plated surfaces, unless lacquered, gradually tarnish to an old pewter color. The plated surface is particularly resistant to atmospheric corrosion and to some other common agents.



Effect of Alloys on Hardness, Ductility, and Strength of Tin

Bismuth is an ideal metal for illustrating crystal growth during solidification, because of its low thermal conductivity, low melting point, and its large characteristic stable crystals. A photograph is reproduced of the crystals resulting from a 1-min. crystallization of about 10 lb. of bismuth in a hemispherical ladle. The beauty of the crystals is enhanced by an iridescent coloring due to an oxide film. The crystals appear to be cubic, but the atoms are really in a rhombohedral face-centered lattice. This atomic arrangement and the brittle nature of the metal are probably cause and effect. At any rate, it has so little ductility that wires could only be made by drawing a heated glass tube containing a rod of the metal. It has later been found that bismuth can be extruded in moderately fine wire, and this wire is used for electrical instruments for measuring the strength of magnetic fields. Bismuth wire has also been used in the construction of delicate thermopiles for astronomical instruments, bismuth against silver having an unusually high thermal electromotive force.

Burgess and Aston in 1909 claimed that the addition of 2% of bismuth to molten electrolytic iron gave a metal of unusual magnetic

properties. They did not report the amount of bismuth found in the solidified metal, but it is probable that very little remained in the treated iron. Recent attempts to check these results have shown no changes in magnetic properties traceable to the bismuth treatment of the molten metal.

Recently, E. K. Smith and N. C. Aufderhaar have found that the addition of bismuth to molten cast iron produced some unexpected results:

(a) Bismuth added to cast iron seemed to increase the fluidity. Molten iron apparently on the verge of solidification, when treated with about 0.5% bismuth, was revivified, the surface becoming clear. Such iron was held in the ladle for a considerable period before it became necessary to pour.

(b) Molding sand peeled readily and cleanly from the castings regardless of the temperature at which the metal was poured.

(c) Bismuth-treated cast iron exhibited much lower tensile strength and Brinell hardness than untreated iron; the reduction in strength amounted to as much as 70%.

(d) Cast iron treated with bismuth was much more machinable than untreated iron.

(e) Very little bismuth remained in the solid iron. Careful analyses by several laboratories has shown 0.002% or less. Smith and Aufderhaar also added bismuth to molten steel and found that the solidified metal from these heats contained only traces of bismuth.

Bismuth added to high grade tin hardens it; copper produces the same result but to a lesser degree. Bismuth-tin alloys are fluid, cast well and at low temperatures, whereas tin hardened with copper requires high casting temperature, does not flow well and does not give sharp, clear-cut castings. The first-mentioned alloys should have distinct possibilities for die castings. Curves shown across give the tensile strength, elongation, and Brinell hardness of some tin-bismuth and tin-copper alloys. All the tests were made on A.S.T.M. cast test bars 0.505 in. diameter and with the elongation rate set at 0.5 in. per min.

The most important use of bismuth other than in the manufacture of pharmaceutical compounds is in the production of low melting and non-shrinking alloys. A comprehensive list of them is given on the data sheet, page 65. This was compiled from the literature by Kent R. Van Horn, of the Aluminum Co. of America's research laboratories, Cleveland, at the request of the non-ferrous data sheet committee of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, and the recommended practice committee of the American Society for Steel Treating.

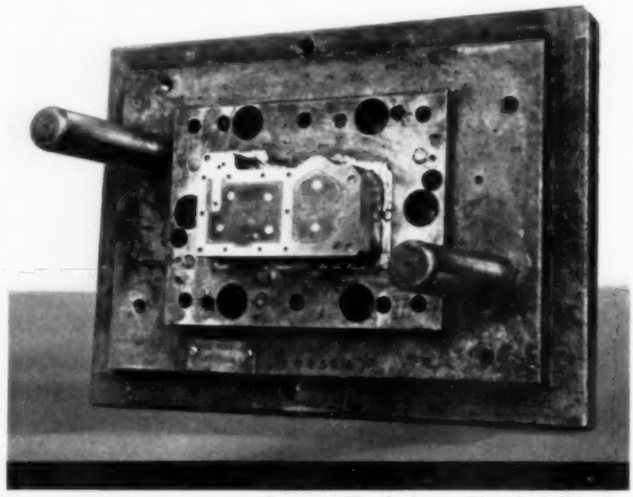
Low melting alloys have been used for the production of dental models, safety plugs for boilers and compressed gas storage cylinders, automatic sprinkler heads, firedoor releases, and low melting solders. The quaternary eutectic of bismuth, lead, tin, and cadmium is perhaps the most fusible of all alloys of common metals not containing mercury. N. F. Budgen, using quite sensitive thermal equipment, determined the melting point to be 149.9 F., although recent work by J. G. Thompson at the Bureau of Standards confirms an earlier determination of 158 F. The ternary eutectic of bismuth, lead and tin melts at 205 F. and the binary eutectic of bismuth and lead melts at 257 F. Modification of the composition of the alloys gives an almost endless series of alloys with melting points between warm water and the melting point of lead. Addition of sufficient mercury to the quaternary alloys depresses the melting point to room temperature.

A number of these al-

Gas-Tight Soldered Joints in Tubing, Metal to Glass

loys listed in the data sheet on the opposite page (particularly those with analyses considerably divergent from the eutectic compositions) solidify over a wide range of temperature. This property gives the particular alloys some value as low melting solders.

Thus, the two photographs at the bottom of the preceding page illustrate water, oil, gas, and vacuum-tight joints between glass and metal tubes. The rough, thin joint was made by a rolling or wiping action, while the more bulky joint was made by casting the alloy in a mold surrounding the joint. It "wets" the glass, but the metal tubes must be "tinned" with the solder before the joints are made. An alloy known as "sealalloy" is now on the market for this purpose.



Courtesy Westinghouse Electric & Mfg. Co.

Trimming Die, 14x9 In., Weighing 500 Lb. Set in Face Plate With Bismuth Alloy

"Dentalloy" is the trade name of another low melting alloy of fairly wide freezing range, which can be cast in plaster of paris molds. It gives perfect reproductions of the cavity and is considerably stronger and harder than some of the other alloys used for dental models.

Thin-walled tubing of various metals is often used, despite the fact that bending and forming are difficult even with the many methods and machines that have been proposed. A filler of some sort is usually required, such as sand, rosin, tar, or pitch. Tubing filled with sand is apt to crimp badly on the inside of the bend. Either rosin, pitch, or tar produces satisfactory bends, but all are difficult to pour into the tubing and are difficult to remove from the finished work.

A low melting alloy sold under the trade name of "bendalloy" makes an ideal filler for tubes having walls on the order of 0.02 in. thick. It melts at 160° F., and therefore can be melted under water, poured (together with the hot water) into the tube and chilled. The tube is then formed to the desired shape. Filling is then completely removed by holding it in a bath of boiling water or steam. The alloy can be used repeatedly without change of composition provided it is not heated in contact with air for long periods of time. Bendalloy filler must be chilled as soon as possible after pouring in order to develop a fine crystalline structure. It will then show as much as 200% elongation in 2 in. under slowly and uniformly applied loads. If allowed to cool slowly, coarse crystals will grow and the alloy may then show as little as 25% elongation in 2 in. Bendalloy will "tin" clean metal surfaces, but commercial tubing generally carries sufficient grease or oxide to prevent this.

A hard, non-shrinking alloy having a solidification range of 248 to 221° F. (known as "matrix alloy") has been employed for mounting and holding the various parts of compound dies, punches, jigs, and fixtures. Matrix alloy discovered by workers at General Electric Co., is believed to eliminate nearly all objections of other mounting materials. It has a tensile strength of about 13,000 lb. per sq.in., and compressive and shear strength sufficient to prevent peening or flowing under pressures developed. It expands slightly on solidifying, and is thoroughly liquid at heats which will not draw the temper of hardened steel.

Fusible bismuth alloys have also been used as liquid seals for the covers of large nitriding and bright annealing furnaces. Another logical use is for low-temperature heat treatment and tempering baths, especially for the light, strong alloys of aluminum and magnesium.

METAL PROGRESS MAY, 1942 PAGE 65

ANALYSES AND MELTING POINTS OF FUSIBLE ALLOYS

Melting Point		Composition, Per Cent					Name or Use	Remarks
Fahrenheit	Centigrade	Bismuth	Cadmium	Lead	Tin	Others		
140	60	53.5	–	17	19	10.5 Hg	Anatomical alloy	
149.9	65.5	49.5	10.10	27.27	13.13	–	Quaternary eutectic alloy	
154.4	68	50	12.5	25	12.5	–	Wood's alloy	Temp. also given as 149.9°F. (65.5°C.)
154.4	68	50.1	10	26.6	13.3	–	Lipowitz' alloy	Temp. also given as 140°F. (65°C.)
158	70	45.3	12.3	17.9	24.5	–	Very fusible alloy	
158 ±	70 ±	44.5	–	30	16.5	5-10 Hg	Fusible tea spoons	
159.8	71	38.4	15.4	30.8	15.4	–	Fusible alloy	
167	75	27.5	34.5	27.5	10	–		
170.6	77	50	6.2	34.5	9.3	–		
176	80	35.3	9.5	35.1	20.1	–		
179.6	82	50	7.1	42.9	–	–		
186.8	86	–	25	25	50	–		
196.7	91.5	51.6	8.1	40.2	–	–	Ternary eutectic alloy	
197.6	92	50	–	30	20	–	Onion's or Lichtenberg's alloy	For fine castings
199.4	93	50	–	25	25	–	D'Arcet's alloy	
201.2	94	50	–	31.2	18.8	–	Newton's alloy	
203	95	50.1	16.6	–	33.3	–		
203	95	55.6	11.1	–	33.3	–		
203	95	50	25	–	25	–		
204.8	96	52.5	–	32	15.5	–	Ternary eutectic alloy	
208.4	98	47	–	35.3	17.7	–		
212	100	40	–	20	40	–		Softens and can be kneaded
212	100	50	–	32.2	17.8	–	Alloy for fine castings	Also given as melting at 205°F. (96.5°C.)
212	100	53.8	–	15.4	30.8	–		Softens at 212°F. without melting
212	100	50	–	12.5	37.5	–		Softens at 212°F. easily oxidized
212	100	59.4	–	14.8	25.8	–		Softens at 212°F.
212	100	57.2	–	17.8	25	–		Becomes nearly fluid at 212°F.
212	100	53.5	–	20	26.5	–		Becomes quite liquid at 212°F.
212	100	50	–	25	25	–	Alloy for fine castings	Becomes very liquid at 212°F.
212	100	50	–	40	10	–		Becomes soft, but does not melt
212	100	50	–	28	22	–	Rose's alloy	Becomes very liquid at 212°F.
217.4	103	40.7	31.4	–	27.9	–	Ternary eutectic alloy	According to Budgen, Journal Society of Chemical Industry, 1924, p. 200.
221	105	48	–	28.5	14.5	9 Sb	Matrix alloy	Solidification range 221-248°F. (105-120°C.)
226.4	108	42.1	–	42.1	15.8	–		
235.4	113	40	–	40	20	–	Bismuth solder	
242.6	117	36.5	–	36.5	27	–		
253.4	123	33.3	–	33.3	33.3	–	Bismuth solder	
257	125	58	–	42	–	–	Binary eutectic alloy	
266	130	30.8	–	38.4	30.8	–		
269.6	132	28.5	–	43	28.5	–		
275	135	58	–	–	42	–	Binary eutectic alloy	
284	140	60	40	–	–	–	Binary eutectic alloy	
289.4	143	21	–	42	37	–		
291.2	144	20	–	40	40	–		
293	145	–	18.2	32	49.8	–	Ternary eutectic alloy	
298.4	148	19	–	38	43	–		
300.2	149	25	–	50	25	–		
300.2	149	22.2	–	44.5	33.3	–		
303.8	151	18.1	–	36.2	45.7	–		
305.6	152	23.5	–	47	29.5	–		
307.4	153	14.8	–	40.2	45	–		
309.2	154	15.3	–	38.8	45.9	–		
309.2	154	14	–	43	43	–		
311	155	17.3	–	34.6	48.1	–		
311	155	16	–	36	48	–		
316.4	158	16.6	–	33.2	50.2	–		
318.2	159	10.8	–	43.2	46	–		
320	160	13.7	–	44.8	41.5	–		
320	160	10.5	–	42	47.5	–		
320	160	11.2	–	44.4	44.4	–		
321.8	161	10.2	–	41	48.8	–		
323.6	162	10	–	40	50	–		
329	165	13.3	–	46.6	40.1	–		
329	165	11.4	–	45.6	43	–		
332.6	167	11.7	–	46.8	41.5	–		
341.6	172	12.8	–	49	38.2	–		
350.6	177	–	23	–	72	–	Binary eutectic alloy	
352.4	178	12.5	–	50	37.5	–		
357.8	181	–	–	37	63	–	Binary eutectic alloy	
		27.5	–	27.5	45	–	Bismuth solder	
		25	–	25	50	–	Bismuth solder	
		47.4	13.2	19.4	20	–	Guthrie's alloy	
		27.2	–	59.2	13.6	–		Alloy for fine castings
		15	–	5	80	–	Various analyses for cliché metal to take impressions	
		9	–	32.5	48	10.5 Sb		
		–	14	50	36	–		
		–	21	46	33	–		

Compiled by Kent R. Van Horn, Research Laboratories, Aluminum Co. of America, for Nonferrous Data Sheets, A.S.S.T. and Institute of Metals

MAY, 1927 PAGE 65
METAL PROGRESS

STRONG *to lift burdens . . .*

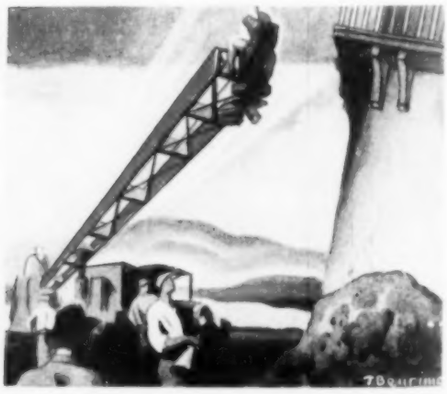
LIGHT *to move*

Hundreds of instances are on record where Alcoa Aluminum has brought lightness, efficiency and permanence into this or that structure. Here are 3 such jobs—all given to the light, strong alloys of Alcoa Aluminum because, having the strength of structural steel, yet only 1/3 of its weight, they are strong to lift burdens yet light to move.

A travelling crane to lift a 10-ton boiler. Alcoa Aluminum's answer was a crane weighing only 30,000 lbs.—23 *tons lighter* than a similar crane made of steel.

For those tough jobs of lifting that face the millwright and rigger, there's a high-geared chain hoist—a regular "sky hook" that, made of Alcoa Aluminum, weighs only 58 lbs., yet will lift a full ton. Job No. 3 was done for the movies. Now when a movie Romeo climbs to a balcony location he's followed by a camera man on a special Alcoa Aluminum boom which weighs only 364 lbs., instead of 900 lbs., for a like boom in steel.

Various alloys have been developed to meet the needs of the designer with whom we are always ready to cooperate. Standard structural shapes of the strong alloys of Alcoa Aluminum are carried in stock. Available also, are strong Alcoa Aluminum alloy plate, sheet, rivets, bolts, nuts, screws. Send $1.00 for your copy of "Structural Aluminum." Address ALUMINUM COMPANY *of* AMERICA; 2501 Oliver Building, PITTSBURGH, PENNSYLVANIA.



ALCOA

ALCOA ALUMINUM

Correspondence and Foreign Letters

Turin, *Italy* — During the last few years, European prices for iron, coal, coke, and oil have undergone great and frequent changes. Prices for these commodities at their origin fluctuated still more sharply to the consumer because of equally frequent changes of freight rates and customs duties. Consequently, a comparison of the manufacturing costs of a given product by different processes would often give a completely different relation, according to the time and the country for which they had been obtained.

Instability of Fuel Prices Delays Plant Improvements

Many instances could be quoted which have led to disastrous industrial results. They would explain why European industry has hesitated to adopt new processes (especially in the last two or three years) for fear that a change in local basic prices might annihilate any advantage of the new, as compared with the old method of operation.

Take, for instance, the problem of introducing large revolving furnaces for melting foundry iron. Fluctuations in prices of fuel had no great importance when considering small furnaces, making only high quality castings, and having to compete with the crucible or the reverberatory furnace. In fact, the oil-heated revolving furnace was rapidly adopted in this branch of the industry.

But things have been quite different for large furnaces, heated with pulverized coal, whose operation had to compete with the cupola. Cost of producing molten iron then had first importance, and depended chiefly on the ratio between the costs of coke and coal. The instability of this ratio in many localities during the last few years accounts for the comparatively slow adoption of the large revolving furnaces by European iron foundries.

At present the prices of industrial materials seem to have been satisfactorily stabilized in Italy, and at their present levels the use of large revolving coal-fired furnaces shows a marked economic advantage when compared with the cupola. Italian iron foundries have therefore begun to replace the latter with revolving furnaces heated with pulverized coal.

A few of these furnaces, described briefly in my letter published last month in Metal Progress, have now been in regular operation for some time, and have given a good account of themselves not only as to costs but also as to quality of products.

Of course, an exact comparison of the cost of melting iron in the two types of furnaces depends in a great measure upon the location of the plant (especially upon its distance from the seacoast and from the coke ovens). But a simple general survey may be based on average prices for fuel.

Assume an average price of coal, suitable

to be pulverized and burned, of 130 lire per ton, and the corresponding price of good metallurgical coke of about 170 lire per ton. While the coke consumption in a cupola, melting low carbon iron, very hot, seldom goes below 12%, the coal consumption in the revolving furnace can be easily kept below 15% while making a similar product. This figures to a very small economic advantage for the revolving furnace: 19.5 lire per ton of iron in the revolving furnace, against 20.4 lire in the cupola.

When the melting losses are taken into account, the advantage of the new process is substantially increased.

When producing very hot, low carbon iron, the gross cupola losses are generally (in this country) about 4%. Losses of silicon and manganese can reach 20 to 25% of the original content of these elements in the pig iron. Losses in the revolving furnace seldom reach 1.5%, with losses of silicon and manganese below 10% of their original percentage.

Under the present Italian market conditions for iron, silicon, and manganese, a melting loss of 1% is equivalent to an increased coke consumption of between 2.5 and 2.7%.

Reckoning with these data, we arrive at a cost of the materials consumed (including fuel and melting losses) more than 50% higher in the cupola than in the revolving furnace.

As the other items forming the total melting cost are rather lower for the revolving furnace than for the cupola, to say nothing of the great technical advantages residing in the former, installation of many large revolving furnaces in Italian gray iron foundries is to be expected within a relatively short time.

FEDERICO GIOLITTI

Castability Varied by 25 Foundry Conditions

PARIS, *France* — FUNDAMENTALLY, the entire art of founding, or the production of castings, is directed toward filling a given mold completely and perfectly with metal. This involves a property of the metal which has been called casting capacity or casting quality. (Isomerism or castability are also good translations of our French word *coulabilité.*) Castability is one of the properties of metals and alloys that have been used to good advantage since antiquity, but which have not been systematically studied nor their fabrication controlled until recent years.

This ability of metal to fill the mold is distinct from its fluidity (with which it is sometimes confused) being a much more complex property. Fluidity of a metal is measured at a constant temperature; both metal and its container are at a uniform heat.

Castability, however, is the performance of metal at unequal and changing temperatures. The metal cools and sometimes begins even to solidify as it fills the mold, which in turn is at a much different heat. Such a property of an alloy is therefore a function of fluidity as it varies with temperature, and also of the crystallization forces within the metal, of its surface tension, and many other foundry conditions surrounding the cooling of the metal in the mold.

More than 25 factors influence the casting quality of metal, and may be divided into five classes:

1. Factors depending on the metal or alloy,
2. Factors depending on the casting circumstances — more particularly on the pouring temperature,
3. Factors depending on the mold,
4. Factors depending on the shape of the piece being made, and
5. Factors depending on the contact between piece and mold.

Such a property, which depends upon so great a number of factors, cannot be analyzed. One must turn to experiments in which the fourth group of factors (concerning the infinite varieties of size and shape of the casting) remains constant. It is therefore customary to cast the metal in the shape of a flat and horizontal spiral, fed at one end; the length reached by the metal is then measured and represents its casting capacity.

In some studies on this subject we made only one factor vary at a time, and found (for the casting capacity determined as above) the following important relationships between the principal foundry conditions:

The chief influence of the mold and dressing depends upon its thermal properties, its porosity, and its cohesion.

Thermal properties of the metal play at least as important a part as its viscosity.

Castability increases with the amount of superheating (that is, the excess of casting temperature over melting point) and is inversely proportional to the difference between the melting point and the temperature of the mold.

Two important factors were discovered about alloys; (*a*) the castability varies inversely as the solidification range, and (*b*) it depends on the form of the crystals which appear at the moment of solidification. The latter influence is greater when the crystals are more or less equi-axed, as would be characteristic of definite compounds, and less in the case of dendrites, as are probably formed when solid solutions solidify. Solid solutions in this respect are akin to pure metals.

By means of these laws, new foundry alloys can be formulated or old ones chosen according to their castability. Or the influence — often very important — of some impurities or the degree of oxidation may be measured. The spiral test piece may also be used to estimate and control the casting temperature for a metal of given analysis, and on the other hand, to reveal alterations in the metal when the casting temperature is at standard.

ALBERT PORTEVIN

Nickel Steels Direct From Complex Ores

OTTAWA, *Canada* — THE present practice of separating nickel from its ores, slagging large quantities of iron in the process, only to alloy much of the metal so laboriously won with iron or steel, has been the incentive to produce nickel-iron alloys direct from the ore. A process for so doing, originated by Colvocoresses, has made several hundred tons of nickel-copper steel from roasted ore. Even though the copper appeared to have an equivalent effect of an equal amount of nickel, the scheme has never been adopted by the steel industry, possibly because of the general assumption by the trade that copper is an undesirable ingredient. This assumption (or prejudice) may in time be abandoned, since the rust-resisting soft steels with about 0.20% copper, and the high strength tubular product with about 1.0% copper have met with undoubted success.

It appeared desirable to find out whether the copper and sulphur could be substantially eliminated from Sudbury ores by commercial equipment, thus producing a nickel-iron oxide which could be smelted or converted into the nickel steels now used so widely. An investigation of this problem was therefore authorized by the Canadian Department of Mines, and conducted by the writer and H. H. Bleakney, his associate on the metallurgical staff.

A representative ore was treated by selective flotation whereby most of the copper and non-metallic minerals were removed, and the nickel concentrate (containing about 48% iron, 3.5% nickel, 0.5% copper, 32% sulphur, and 16% gangue) was roasted to 0.2% sulphur in a multiple-hearth Herreshoff furnace. The iron was then converted to magnetic oxide by roasting at 1100° F. and cooling in a city gas atmosphere. Magnetic concentration gave us a fine material containing 62% iron, 1.5% nickel, 0.4% copper, 0.10% sulphur, and 6% insoluble.

This can be reduced to metal and alloyed in a variety of ways. It would be desirable to sinter it first, but we treated it immediately in an

electrically heated, rotary retort suitable for low-temperature reduction of iron ore by bituminous coal. The crude sponge was again treated in a magnetic separator and briquetted. It then analyzed 83% iron, 6.10% nickel, 0.60% copper, 10.3% non-metallic.

All these operations are well known to the ore dressing and non-ferrous smelting industry, and there should be no difficulty in making a briquetted nickel-iron sponge which would be a convenient and practical means of introducing nickel into steel and cast iron.

In order to demonstrate its usefulness, a series of S.A.E. steels was made from the briquettes in a 50-lb. high frequency furnace. Comparison ingots were made of boiler plate punchings and electrolytic nickel (together with other ferro-alloys as necessary).

Recovery of nickel and copper from the metal sponge was practically perfect. All the ingots rolled easily into 1-in. rounds, and pieces were heat treated in a variety of ways. Tests made on standard tensile and impact tests indicate that the steels made from nickel-iron sponge are quite comparable to steels made from the usual raw materials. From a great number of results given in Memorandum Series No. 54 of the Mines Branch, Canadian Department of Mines, the following may be quoted and compared with values scaled from the corresponding S.A.E. curves.

	From Briquettes	From Metal	S.A.E. Value
Tensile strength	115,000	115,500	120,000
Yield point	98,500	102,500	93,000
Elongation in 2 in.	24	24	18
Reduction in Area	59	64	63
Brinell hardness	235	241	235

In tests from which the above results were taken, 1-in. rounds of 3% nickel steel (S.A.E. 2330) were all quenched from 1475° F. into water and drawn at 1000° F.

While this work leads to no conclusion as to the economics of the process, it should have commercial possibilities, as none of the steps are difficult or unusual.

THOMAS W. HARDY

Aluminum in Brass Causes a Resistant Surface Film

LONDON, *England* — THOSE who have followed modern metallurgical developments, especially regarding materials intended to resist corrosion, will be familiar with the importance which is now attributed to the surface film on metals.

The idea that such a film exists has long been present in the minds of investigators, not deterred by the fact that the film is invisible to the naked eye and even to the most powerful microscope when applied in the ordinary way. Another school of thought, however, tried to explain the phenomena of corrosion and resistance to corrosion exhibited by certain materials on a different basis.

The final proof has been given by Evans and others who have actually isolated the film. While it is invisible when attached to the surface, after the metal itself is removed by a suitable chemical agent, the delicate surface film is left behind. It is now clearly realized that the rust-resisting properties of steels containing considerable proportions of chromium (or of nickel and chromium together) are due to the toughness and chemical inertness of a film containing a sufficient proportion of chromium oxide.

It is well known that chromium is not the only element which has this property of producing a chemically resistant covering. The very existence of aluminum in an atmosphere containing moisture and oxygen is due to the presence upon that metal of a particularly strong film of oxide. Beryllium, a metal which has only lately been studied to any considerable extent, possesses the same property. These two light metals, like chromium itself, appear to confer upon the surface film of any metal with which they are alloyed at least some of the resisting power which they themselves possess. Use of beryllium for this purpose has not yet been developed.

So far as steel is concerned, the possibility of utilizing *any* metal in this way depends upon the influence which it exerts upon the mechan-

ical properties of the alloy when present in sufficient quantity to render the oxide film chemically resistant. The case of chromium is fortunate. Presence of aluminum in steel, however, is not usually regarded as desirable, and when the proportion added is sufficient to produce a resistant surface film, the resulting steel is not of a very serviceable quality (alloy steels for nitriding are excepted).

Recently, certain alloys of iron with larger amounts of aluminum have been prepared which show very interesting properties, particularly at elevated temperatures. The resisting power of the oxide film, when sufficient aluminum is present, protects these steels in these circumstances not so much against atmospheric corrosion as against oxidation and other forms of attack at high temperatures. The fundamental principle behind this application of an aluminum-iron alloy is, however, the same as that involved in the use of chromium steels for withstanding corrosion.

It is further interesting to note that the valuable qualities conferred upon an oxide film by the presence of such a metal as aluminum are by no means confined to steel. We have long recognized the corrosion-resisting properties of the so-called aluminum bronzes (alloys of copper with 7 to 10% aluminum, to which sometimes nickel, manganese, or iron are added). Thanks to investigations carried out by the British Non-Ferrous Metals Research Association, it has been discovered that it is not necessary, in order to secure the protective effect of aluminum in the surface film, to make the alloy a true aluminum bronze. An aluminum brass containing about 2% of aluminum possesses properties which make it a very valuable material where resistance to corrosion is important. It has been found by practical trial as well as by laboratory experiments that condenser tubes made of this aluminum brass are particularly successful both on land and at sea. They are also less costly than tubes of cupro-nickel which are advocated for use where corrosive conditions are rather difficult.

This particular case is of interest for two reasons. In the first place, it promises to be a large-scale result of importance obtained by cooperative research, of which the work of the British Non-Ferrous Metals Research Association is a typical example. Aluminum brass, which is the result of this cooperative research, is being manufactured and marketed both in this country and in America by a number of the firms which have contributed to the cooperative research; naturally none of them are able to claim any exclusive rights, although no doubt the products of different firms may differ as the result of varying methods of manufacture, in the extent to which they realize the best possible results in the fabrication of this particular non-ferrous material.

From another point of view, the use of this aluminum brass as a corrosion-resistant material is interesting because it appears to be the first example, on a large scale, in which the method of developing an alloy having a natural protective film, analogous to that of the chromium steels, has been applied in the non-ferrous field. Of course, many alloys consisting mainly of aluminum naturally possess such a film, and the strengthening of this film by anodic oxidation is also a well-known process. It is, however, a step in another direction to make an alloying addition of aluminum for the essential purpose of producing a surface film more resistant to oxidation.

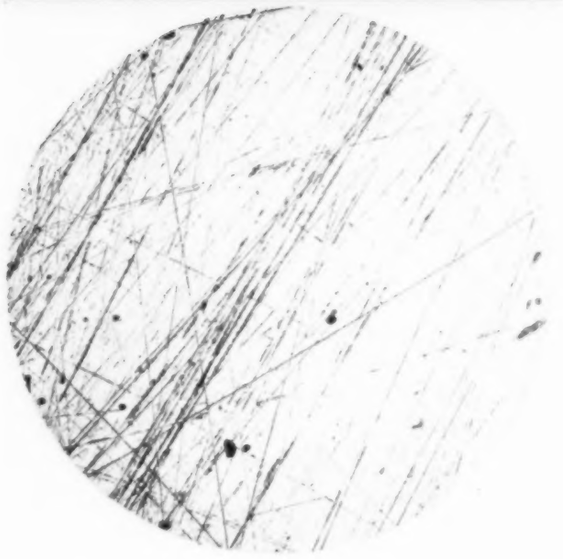
There is much room for further work of this kind in the non-ferrous field, where "stainless" alloys are not yet as well developed as they should be. While, in the long run, each metallurgical material is likely to find its proper use, from which the competition of rivals cannot dislodge it, there is no doubt that the rust-resisting steels are at present seriously rivaling some of the non-ferrous alloys in applications which have formerly been confined to the latter. In these circumstances we may well expect, in the near future, a vigorous effort to produce "stainless" copper alloys, and perhaps aluminum brass may be regarded as an interesting step in that direction.

WALTER ROSENHAIN

BLACK MAGNETIC ROUGE POLISHES RAPIDLY AND WITHOUT FLOW

By Prof. Welton J. Crook and Warren R. Philbrook

Stanford University California



Finished by Oiled Emery Paper, No. 0000. Unetched. Magnified 100 diameters

IN THE PREPARATION of specimens for metallographic examination, the final polishing is the most tedious and time-consuming part of the entire series of operations; nevertheless, the degree of perfection arrived at is one of the most important factors in producing surfaces which truly represent, after suitable etching, the microstructure. For this reason any method of polishing or any polishing medium which gives quicker or more perfect results should be of interest.

In the past 10 or 12 years, the polishing procedure followed in the metallographic laboratory of the Department of Mining Engineering at Stanford University has undergone a gradual evolution. When work of this character was first undertaken, the steps were as follows: Coarse emery on canvas, fine emery on canvas, tripoli on fine canvas, and finally rouge on black broadcloth. Small horizontal revolving disks served as a support. Preliminary grinding was done on small alundum wheels of varying grit fineness. This procedure had many disadvantages, among which were out-of-flat finished specimens caused by wear on the alundum wheel, and metal surfaces cold

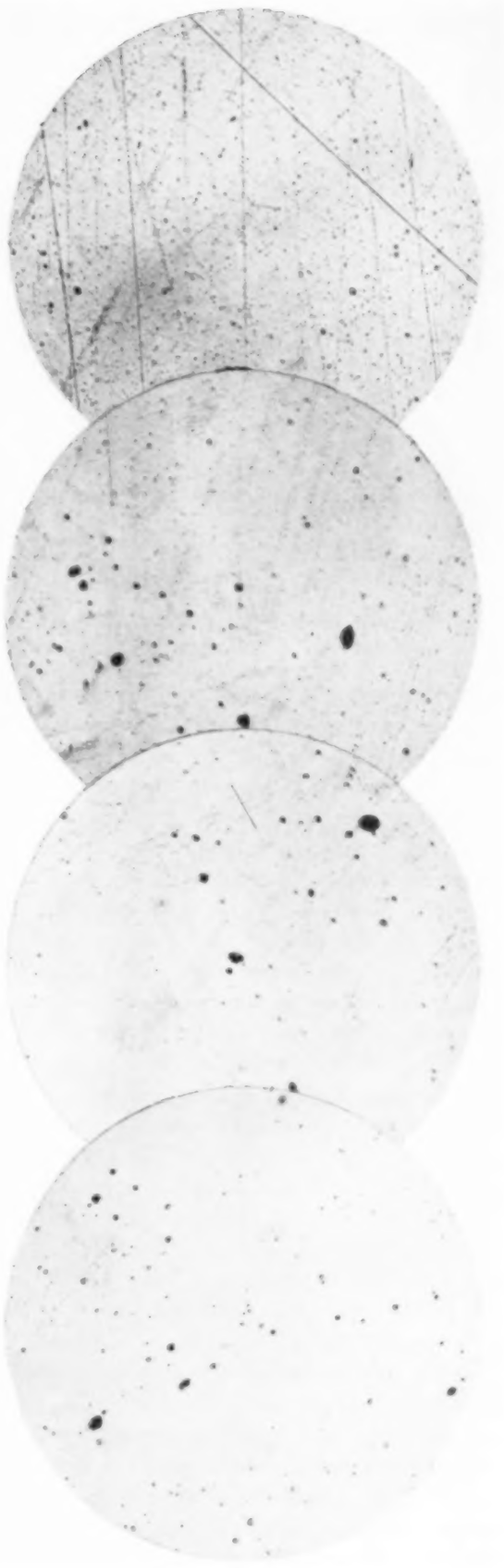
worked by the fine emery and tripoli powders.

The first change made was the substitution of hand polishing on No. 0, No. 00, No. 000, and No. 0000 emery papers for the finer grades of alundum wheels and the emery and tripoli powders. We retained the final rouge polishing. This procedure gave better results but it required excessive time for the paper polishing, and the final rouge polishing developed too much flowed metal.

The next general change was the use of surface grinders supplied with three grades of belts. By the use of these machines, the surface left from milling or shaping could be made ready for hand polishing on No. 0 emery paper in a minimum of time and, in addition, a flat surface was insured. It was then found that the use of No. 000 emery paper was an unnecessary operation. The new sequence was No. 0 and No. 00 dry, and finally No. 0000 with a light machine oil. In this last operation the specimen was given a circular motion.

When these changes were made a substitute for the rouge was also sought. Prepared magnesia and other final polishing powders on the market were costly. Magnesia was also undesirable on account of the formation of magnesium carbonate on the polishing head. We then prepared aluminum oxide in the laboratory from chemically pure ammonium alum. This compound was first slowly heated in a porcelain dish to drive off the water of crystallization, and the temperature then slowly raised in an electric muffle furnace to drive off the ammonia and sulphate radicals. Final ignition was at 1850° F. for several hours. After testing for acidity, the soft lumps were broken up and the aluminum oxide suspended in water. With this material the specimen was given a final polish on large horizontal revolving disks covered with hat felt.

The sequence (*a*) surface grinders, (*b*) No. 0, (*c*) No. 00, (*d*) No. 0000 emery paper, and (*e*) alumina on hat felt, was used satisfactorily for several years except that the various batches of alumina did not always give uniform results. Furthermore, extreme care in preparation was necessary to avoid grit which would scratch the sample. We



Black Rouge Finish

Unetched Surfaces After Polishing 1, 2, 3, and 4 Min. With Black Magnetic Rouge on Felt

Soft Steel Three Months in Reheating Furnace. Etched with nital. Magnified 100 and 1000 diameters

lately ground the alumina in a ball mill to break up lumps and secure a finer state of division. This showed some promise, and would have been adopted as a regular procedure if another material had not been found.

We were drawn to this by M. N. Short's discussion of the polishing procedure for mineral surfaces, given in "Microscopic Determination of the Ore Minerals," published by U. S. Department of the Interior as Bulletin No. 825. He recommends either magnesia or "black magnetic rouge," and states:

"'Black magnetic rouge' is a polishing powder manufactured by Binney and Smith, 41 East 42nd St., New York. Its use was recommended to the Geological Survey by Prof. Alan M. Bateman. According to the manufacturers, it is obtained by a patented process of precipitation and consists of 99% Fe_3O_4. In general, it has the same effect as magnesia but does not cut as fast. It is the best medium for polishing soft minerals, such as galena and chalcocite."

The price of this material was found to be 30¢ per lb. A quantity was obtained, suspended in water and used as a final polishing medium without levigation. From Mr. Short's statements it was expected that the black rouge would be unsuitable for the preparation of steel specimens on account of a lack of cutting power. So a trial was made on two steel specimens, one a gage block of extreme hardness (Rockwell C-64) and the other quite soft, an annealed low carbon steel having a hardness of only Rockwell B-60.

Both specimens were polished to a satisfactory metallographic surface with great rapidity. The softer specimen was then repolished on 0000 paper with oil, and again finished with the black rouge. Photographs of the surfaces taken before starting and after each minute of black rouge polishing show the rate of progress achieved.

Results are so good that the use of black oxide rouge has become standard practice in the metallographic laboratory at Stanford University. It is cheaper, cuts faster, and gives more perfect surfaces than any material which has so far been tried. Its only apparent disadvantage is the persistence with which its color remains on clothing, hands, and equipment.

The specimen used for the illustrations is, perhaps, not without interest. It was taken from a piece of low carbon steel, which was originally a 4x4-in. billet but was lost in a steel mill heating furnace. After about three months at heating furnace temperatures, the billet had decreased in size to a roughly round section having a diameter of only ¾ in. Is it not possible that the etched specimen discloses the maximum grain size which can be obtained when rolled soft steel is held at a high heat?

The peace that pennies buy

EACH DAY, after breakfast, you bid good-bye to your husband and he is gone. Miles of distance and hours of traveling may separate him from you, yet you do not fear. You have no feeling of his being far away — no sense of loneliness or isolation. For there, within reach of your hand, is your contact with all the world — the guardian of your home . . . your telephone.

All you see is the telephone instrument itself and a few feet of wire. Through the familiarity of use, you are likely to take it for granted in much the same manner as air and water and sunshine. Rarely do you think of the complicated exchanges, the almost endless stretches of wire and the hundreds of thousands of trained employees that are needed to interconnect, through the Bell System, nearly twenty million telephones in this country and twelve million in foreign lands. No matter where you are you can command the full use of the telephone. It knows no class or creed. There is no distinction of position. All may share it equally.

Every time you lift the receiver you employ some part of the nation-wide Bell System. Yet the charge for residential use is but a few cents a day. For this small sum you receive a service that is almost limitless in convenience and achievement — so indispensable in emergencies that its value cannot be measured in terms of money.

Thinking of the peace and security it brings each home — of hurried calls to doctors and hospitals — of priceless, necessary talks with relatives and friends — of the many ways it saves you steps and time and trouble throughout the month, you will know why so many millions of people look on the telephone as a member of the family.

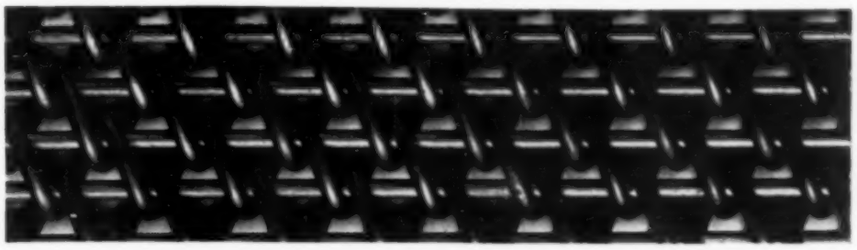
AMERICAN TELEPHONE AND TELEGRAPH COMPANY

CONCENTRATES FROM THE LITERATURE

TWO dozen reports on **BERYLLIUM**, the light metal, have been translated from the German by R. Rimbach and A. J. Michael in a 330-page book published at $10 by Chemical Catalog Co., New York. These researches were financed by the Siemens Co. and performed by Messrs. Masing, Dahl, Illig, and Fischer during the period 1923 to 1929. A workable method of producing the metal was discovered by Stock and Goldschmidt about 1920, and this has been commercialized by the above group. It consists of electrolysing a molten mixture of berryllium oxyfluoride and barium fluoride. A graphite crucible is the anode, a water-cooled iron pipe is the cathode, and a rod of beryllium collects as the latter is gradually withdrawn. Temperature is about 2550° F. Remelting under salt gives a 99.6% metal. Most of the book is concerned with the age hardening properties of copper, bronze, iron, and nickel-chromium steel containing a little beryllium. Copper-beryllium alloys may be hardened to 500 Brinell, and nickel-chromium-beryllium steels to 700 Brinell. Students of metallurgical theory will be interested in the discussion of the essential mechanism of **AGE HARDENING** in the light of the data obtained during these investigations. Dr. Masing apparently believes that the maximum result in copper-beryllium alloys is accompanied by no great rearrangement of atoms in the solid solution, but that adjoining atoms of different elements move within range where valence forces, formerly inactive, can come into play and thus germinate definite chemical compounds. Fragments of a new space lattice are thus formed in the main body of solid solution.

WEB, flange, and outside of the head of a hot rail cool fairly rapidly and the rate of contraction is small, whereas the interior of the head will be at a higher temperature and will therefore be contracting more rapidly. These differences set up tensional strains within the head which result in shatter cracks and **INTERNAL FISSURES.** These cracks, originating on the cooling bed, can be substantially prevented by temperature equalization in the "Sandberg oven," a process described by the Messrs. Sandberg in *Metals & Alloys* for April, which has been successfully used in the plants of several British rail makers. This is a preheated chamber into which the rails are placed after they have cooled to 925° F. and held without further radiation or conduction of heat from the surface until they have a uniform temperature throughout. Cooling is then partially retarded until a temperature of 650° F. is reached, when tensile strength and rigidity of the outer surface avoid danger from contraction strains.

INCREASED resistance to fatigue can be secured in automotive **CONNECTING RODS** by breaking down the shank section in a rolling mill before forging instead of by the old method of roughing out between fullers. Gentle squeezing of the metal between rolls results in straight, even flow lines instead of the wavy, crooked lines which were an inherent weakness of rods made in the old way. This method has been adopted by Cadillac Motor Car Co. and is described by L. A. Danse in *The Iron Age* for April 11. The billet of S.A.E. 1140 steel is given nine



Spiral Type Conveyor Belt with Straight-Rod Reinforcement.

PATENT GRANTED

on

STRAIGHT-ROD REINFORCEMENT

NUMEROUS patented and special features have long been identified with Wissco Metal Conveyor Belts . . . each one adding to the efficiency of the application of Wissco belts to many manufacturing operations such as washing, drying, dyeing, annealing, baking and otherwise conditioning materials.

And now the Wickwire Spencer Steel Company has been granted U. S. Patent No. 1,850,859 covering the use of Straight-Rod Reinforcement which provides for a belt of spiral weave construction supplied with straight wires extending across the belt in the hinges of the spirals. These wires are securely held in position, and thereby assure the maximum of belt efficiency by providing a uniformly flat surface under working conditions, and by preventing lateral contractions it lessens stretch under the loads, tensions and temperatures to which the belt may be subjected.

All the features pertaining to the use of this straight-rod reinforcement, as covered in the granting of this patent, will be fully protected by the Wickwire Spencer Steel Company.

Let us explain in detail why Wissco Spiral Type Conveyor Belts are standard in industries where belts are employed for the handling and conditioning of practically every class of material.

Wickwire Spencer Steel Company, 41 East 42nd Street, New York City

Buffalo, Chicago, Detroit, Philadelphia, Tulsa, Worcester; *Pacific Coast Headquarters:* San Francisco; *Branches and Warehouses:* Los Angeles, Portland, Seattle; *Export Sales Department:* New York City.

WISSCO
CONVEYOR BELTS

Tungsten Powder	97-98%
Pure Manganese	96-97%
Ferro-Chromium	60%
Pure Chromium	97-98%
Ferro-Tungsten	75-80%
Ferro-Titanium	25%
Ferro-Vanadium	35-40%

(1% Silicon)

SEND FOR PAMPHLET NO. 2021

METAL & THERMIT
CORPORATION
120 BROADWAY, NEW YORK CITY
PITTSBURGH · CHICAGO · S. SAN FRANCISCO · ALBANY · TORONTO

Columbia
TOOL STEEL

CLARITE HIGH SPEED STEEL
OILDIE NON-SHRINKING
COLUMBIA SPECIAL CARBON TOOL STEEL
COLUMBIA EXTRA, ETC.

It pays to use Good Tool Steel.

COLUMBIA TOOL STEEL COMPANY
MAIN OFFICE AND WORKS
500 E. 14TH STREET, CHICAGO HEIGHTS, ILLINOIS

CHICAGO	HOUSTON	NEW ORLEANS	ST. PAUL
CINCINNATI	KANSAS CITY	NEWARK	SAN FRANCISCO
CLEVELAND	LOS ANGELES	PORTLAND	SHREVEPORT
DETROIT	MILWAUKEE	ST. LOUIS	WORCESTER

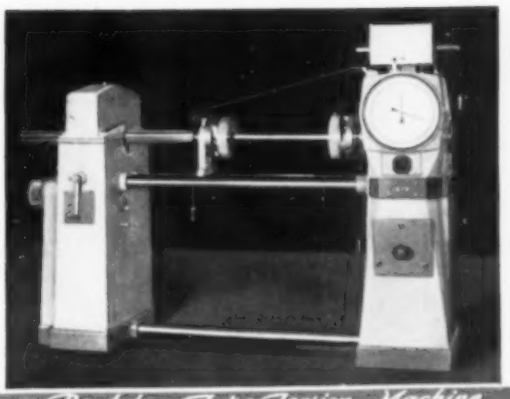
passes in an "interrupted," "push-back," or "gun-barrel" type of roll, reheated, the end flattened, edged, finish forged, trimmed, restruck, pickled and inspected. The connecting rod is then heat treated to a Brinell hardness of 255 to 293. Occasional rods are macro-etched to reveal forging flow lines and some are given an Upton-Lewis fatigue test. This machine was designed to test the complete connecting rod instead of merely a test specimen, and therefore serves as a check upon structure and design as well as upon material.

THIN sheets are thicker at the center than at the edge not because the rolls spring but because of "elastic restoration" of the hot metal itself, in the opinion of W. H. Melaney in articles appearing in *Blast Furnace & Steel Plant*, January and April. Ordinarily this phenomenon is more noticeable the larger the diameter of the rolls, thus ruling out the roll deflection theory. Pinched **SHEETS** occur, in his opinion, when the edges are nipped between the rolls before the center, and the metal is forced to flow toward the center where it piles up and laps over. Much more care should be taken with the roughing rolls to insure sheets correct in final cross-section; most troubles in the finishing stands will then disappear. Steam pipes for cooling rolls should have a number of openings of various sizes so the most steam bathes the center of the roll and less and less as the ends are approached, since the ends normally are cooled by conduction through the roll necks. In this way the correct crown or contour of the rolls may be maintained.

RECENT literature on molybdenum-iron alloys has been searched by Messrs. Gregg and Gillette of Batelle Memorial Institute and a summary published in *Metals & Alloys* for April. During the last two years specific information on the properties of medium manganese steels (either cast, rolled, or forged) containing fractional percentages of **MOLYBDENUM** has been printed, thus making public

what was formerly known to some large users of this excellent combination. It also appears that similar additions to a great many steels will increase their creep limits or their rate of plastic flow under load at high temperature, and the fact is utilized by most manufacturers of superpower or petroleum refinery equipment. Molybdenum (0.35 to 0.75%) is becoming a common constituent of special gray iron castings, notably automotive brake drums. Improved strength and wear resistance are secured without increasing machinability unduly. The element also reduces mass effect — that is, test pieces cut from large castings are almost as strong as from small ones. Practice in all branches of the industry seems generally to follow that of some years back — to use molybdenum in small amounts with one or more other alloying elements, thus intensifying or equalizing the effect of the latter, or introducing some valuable subsidiary quality difficultly obtainable without it.

AN accelerated test for determining the limiting **CREEP STRESS** of metals, which was discussed recently by W. Barr and W. E. Bardgett before the British Institute of Mechanical Engineers, is described in *Metallurgia* for March. The specimen is placed under tension in a steel weigh-bar or yoke. Stress in the specimen is measured by extensometers on the yoke, which of course is entirely outside the furnace. Rate of decrease of the measured stress is proportional to the relief of stress by extension of the heated test specimen. A resistance-wound furnace 24 in. long encloses the specimen and temperature is controlled to within ± 1.0 F. The extension of the weigh-bar is measured accurately; elastic movements corresponding to 3-lb. stress are determined, corresponding to an extension of the test piece of 7×10^{-6} in. per in. By plotting stress against time for a series of tests using different initial stress, it was found that initial stress was approximately proportional to decrease in stress in a given time. Then, by plotting initial stress against decrease in stress, a straight line is located which cuts

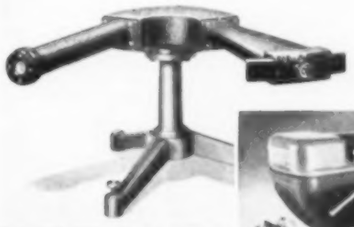


Pendulum Type Torsion Machine

RIEHLE again

has Something New for You

RIEHLE has developed a new Pendulum Type Torsional Testing Machine—and you'll like it. • In the first place, it's a multiple (three) scale range machine, with all scale ranges on a single dial. Transition from one scale range to another is simply accomplished by pushing the "scale range change rod" to any of its three positions. • Second, the pendulum recoil apparatus is hydraulic (and positive) in action. You can have hand operation, or fast or slow motor operation. Grips take specimens from $\frac{3}{16}$" to $3\frac{1}{4}$" diameter. And the autographic recording apparatus is flat, its story is before your eyes during the entire test. Send for literature if you are interested, we'll be glad to send it.



Steeloscope

The Steeloscope (for determining alloy elements in steel) is made by Hilger in England and sold in U. S. by Riehle. The Vickers Hardness Tester (right) will tell you more about hardness than any other machine.

Vickers

RIEHLE BROS.

TESTING MACHINE COMPANY

1124 N. NINTH STREET, PHILADELPHIA, PA.

WEAR-RESISTANCE CAN BE IMPROVED

with

NICKEL CAST IRON

Leading engineers and manufacturers find in Nickel Cast Iron the answer to today's demand for improved wear-resistance. That's because no ordinary cast iron can render equally good performance...can give users such oustanding service records. If you are interested in obtaining higher and more uniform hardness...greater strength and toughness...improved machinability, specify Nickel Cast Iron.

THE INTERNATIONAL NICKEL COMPANY, INC.
Miners, refiners and rollers of Nickel.
Sole producers of Monel Metal.
67 WALL STREET **NEW YORK, N. Y.**

Nickel CAST IRON
A BETTER MATERIAL FOR MODERN NEEDS

Convenience in Hardness Testing

Makes for **SPEED, ECONOMY, ACCURACY**

The MONOTRON has now come into general use by descriminating establishments because:

A. It has the required Adaptability and convenience in operation upon which speedy and satisfactory service depends.

B. Two Dials show more than any one Dial tester, solving problem of application to all known materials of any hardness.

Not Most Expensive Machine to Install.

For additional information see our Bulletins M-3, M-5. Free upon request.

The MONOTRON

For a Good Single Dial Tester We Offer The SCLEROSCOPE
(Latest Improved)

Quick, accurate, more popular than ever, it has the only simplified (Centigrade) scale which is understood and quoted the world over. The only tester that is 100% portable, and operative on work of unlimited size. Accurate conversions to Brinell.

Bulletins S No. 22 and S No. 30 mailed free.

The SCLEROSCOPE, 100% Portable

THE SHORE INSTRUMENT MFG. CO.
Van Wyck Ave. & Carll St. Jamaica, New York, N. Y.

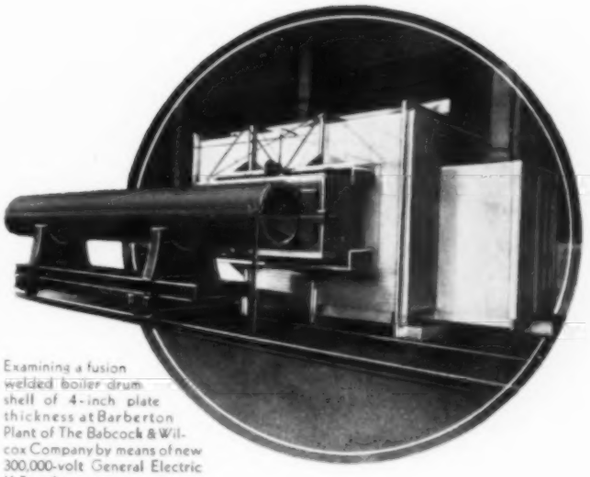
the initial stress axis at a value which will give no measurable decrease in stress in the test period (48 hr. giving accurate results). This must correspond to a total creep of 7×10^{-6} in. per in. or 1.45×10^{-7} in. per in. per hr., a much higher figure than the average rate over extended periods. By such means it was found that the limiting creep stress of annealed steel (0.23% C, 1.67% Mn) at 400° C. (752° F.) is 9750 lb. per sq.in. and at 500° C. (932° F.) is 3920 lb. per sq.in.

WIRE rod consisting of a single crystal; a galvanizing kettle which is cooled instead of heated (more than enough heat is conveyed to the spelter by the wire); discontinuation of pickling and baking — these are some of the advances in the **WIRE DRAWING** industry which were predicted by Kenneth B. Lewis in an interview published in *The Iron Age*, April 7. Most important immediate change in practice, however, will probably be the use of larger rod with extra drafts, as, for instance, 0.3125 in. diameter with three or four drafts instead of the present 0.207-in. rod with one or two drafts. In continuous drawing the number of drafts does not seriously affect labor costs, and wire so made is stiffer (thereby permitting smaller diameters), is cleaner and easier to galvanize, and can be produced in larger bundles — a fact which is of importance in reducing handling costs. Although die design is far ahead of other details of the wire industry, Mr. Lewis believes there is still important work to be done in analyzing forces operating on a die, and in improving lubricating films.

CORROSION of metal underneath electroplates will be prevented when steel and plate properly adhere, and this in turn depends principally upon the cleaning technique, according to Marvin J. Udy in *Mining & Metallurgy* for April. The inherent weakness of present **CLEANING PROCESSES** is that, while they remove grease and rust, they produce or leave behind a very thin film of oxide, caustic,

or gas. In the so-called Madsenell process for making ductile nickel plates, the final cleaning treatment is in 59° Bé. sulphuric acid, which removes the gas, but the acid must then be removed by very rapid and efficient washing. Dry cleaning is one suggestion of merit. Sand blast, emery cloth, or dry grinding will serve excellently for simple shapes; degreasing with trichlorethylene vapor is also giving good results in the chromium plating department at Frankford Arsenal. Prompt immersion of the cleaned article in the plating bath is essential.

A GOOD measure of the increasing use of welding in American battleship construction is the fact that on the 22nd month of construction of the New Orleans, the latest 10,000-ton treaty cruiser, 4 riveting gangs and 28 welders were engaged, whereas at the corresponding period on the Pensacola, the first to be built, there were 14 riveting gangs and 8 welders. Capt. J. O. Gawne discussed this matter of **SHIP WELDING** comprehensively at the New York meeting of the American Welding Society last month. The bow of this ship, about one-sixth its length, is almost completely welded. Perhaps 90% of the rest of the carbon steel plating, bulkheads and stiffeners, transverse beams and inner hull are welded. Heat treated alloy steel in side and deck armor and in high strength members is riveted, as is the load-bearing structure of mild steel amidships. Foundations for auxiliary machinery, catapults, and anti-aircraft guns are of welded steel, also most of the fittings and the deck erections, whereby much weight is saved. Labor costs of flat, straight seams made in the shop are less than for riveted joints, but this is lost in extra work for fitting and erection. Riveting is generally quicker but requires more men and machinery. Welders must qualify by making joints with bare electrodes in 0.20 to 0.30 carbon steel plate which develop at least 45,000 and an average of 52,000 lb. per sq.in. With heavily fluxed electrodes the test results are 10,000 to 15,000 lb. better, but especial care and training are necessary to avoid undercutting. Designers



Examining a fusion welded boiler drum shell of 4-inch plate thickness at Barberton Plant of The Babcock & Wilcox Company by means of new 300,000-volt General Electric X-Ray Apparatus.

Babcock & Wilcox install 300,000-volt x-ray plant

FUSION welding of boiler drums four inches and more in thickness is routine procedure at the Barberton Works of The Babcock & Wilcox Company. To insure sound welds, equal to or better than the plate metal, they have recently installed the latest and most powerful type General Electric x-ray apparatus, for non-destructive radiographic examination of the completed weld.

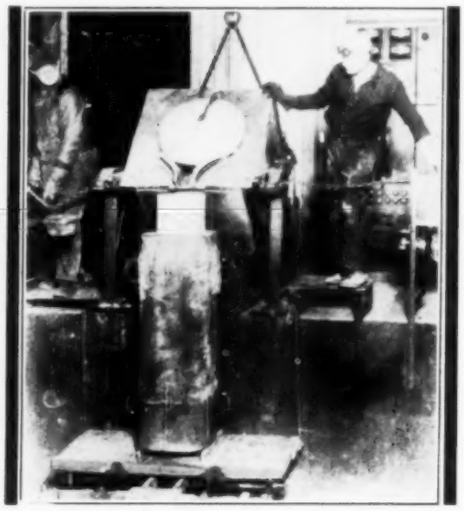
Operating at a potential of 300,000 volts at 10 milliamperes, Babcock & Wilcox find that this equipment "will thoroughly explore, on a production basis, fusion welded seams up to 4¾ inches in thickness."

This is but one of the many specialized G-E industrial x-ray plants which are being installed for the examination of welds, castings, rolled and drawn materials, hidden assemblies, etc., and for crystal analysis. In practically every production process where hidden defects present a problem the x-ray can be profitably used. In many cases the x-ray negative has pointed the way to improved manufacturing methods which have eliminated the defects.

Let us keep you informed on the latest developments in this field. Literature describing and illustrating the many industrial applications of the x-ray will be sent on request. Address Industrial Department.

GENERAL ELECTRIC
X-RAY CORPORATION
2012 Jackson Boulevard **Chicago, Illinois**

Join us in the General Electric program broadcast every Sunday afternoon over a nationwide N. B. C. network.



AJAX-NORTHRUP
Coreless Induction Furnaces

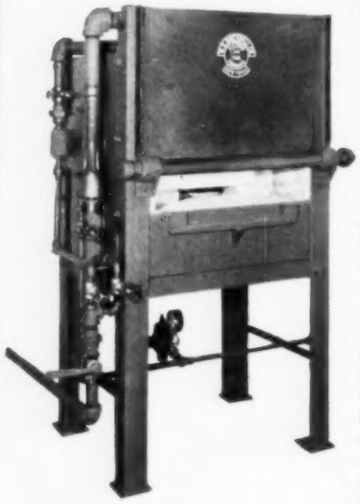
Write for Information

Ajax Electrothermic Corporation
Trenton, New Jersey

G. H. CLAMER
President and Gen. Manager

E. F. NORTHRUP
Vice Pres. and Technical Adviser

Produce BETTER FORGINGS



Reduce your fuel bill and improve working conditions with this ROCKWELL Economizer Shield Type Forge Furnace. Its advantages, under actual operating conditions in the manufacture of nuts, bolts, rivets, axles, automobile parts, etc., as well as for miscellaneous forging, and upsetting operations, have been found to include:

More uniformly heated product . . . Saving of fuel and power through the use of low pressure air . . . Reduction in fuel consumption through utilization of heat in spent gases to preheat the air and fuel . . . . Less shop area for same output by reason of better working conditions.

Write for Catalogs No. 274-321-C

W. S. ROCKWELL CO.
Industrial Heating Equipment
50 CHURCH ST. (Hudson Terminal Bldg.) NEW YORK
Detroit Chicago Columbus Cleveland Indianapolis Montreal Toronto

figure 36,000 lb. per sq.in. ultimate strength in tension and 29,000 lb. per sq.in. in shear. This discounts the qualification tests, and allows for the workman's personal variations, day to day, and the internal stresses existing within rigid joints. A factor of safety of four brings the unit design stress down to less than 10,000 lb. per sq.in., which is probably a fair figure for the fatigue strength. Factor of safety of 12 is applied to joints that must resist impact.

SOME duralumins are subject to intercrystalline corrosion; surface appearance and tensile strength are not changed noticeably, but elongation is markedly reduced. Another of a numerous list of investigations on this sporadic defect was presented by Messrs. Sidery, Lewis, and Sutton before the March meeting of the British Institute of Metals. Several reagents, supposed to accelerate this form of **CORROSION IN DURALUMIN**, were investigated; a normal solution of NaCl to which 1% of HCl was added was found to produce consistent results. Overstrain in tension of heat treated duralumin did not increase intercrystalline penetration, but compression between the range of 31,000 and 38,000 lb. per sq.in. caused susceptibility. It was also found that the higher the quenching from the range 870 to 960 F. the smaller the tendency to intercrystalline corrosion in room-aged specimens. Boiling water is not nearly as good as cold water for a quenching medium, as far as resistance to the special reagent is concerned.

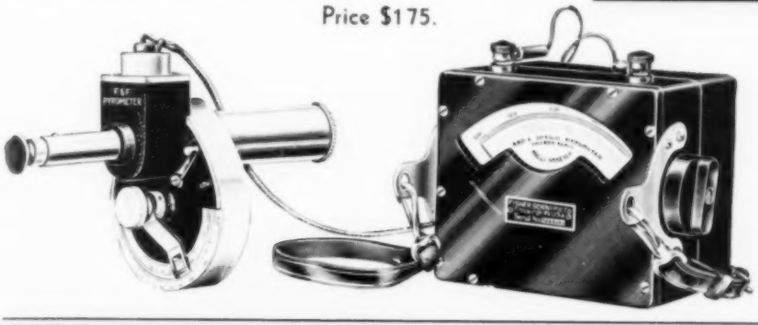
WELDED steel barges are not built to save weight but experience with nine of them indicates they can compete with wooden construction, according to Gordon G. Holbrook of Federal Shipbuilding & Dry Dock Co., speaking before the American Welding Society last month. In his design of **WELDED BARGES** all plating for bottom, sides, and deck is made by laying 15-in. steel channels side by side (the flanges separated by a bar which projects slightly both top and bottom) and welding the joints in a continuous seam by a shielded carbon

TEMPERATURE READINGS BY OBSERVATION

. . . TO take a temperature reading with the FISHER & FOOTE Optical Pyrometer, observe the heated object through the telescope, rotate the knurled-head as directed and read the temperature directly on the scale of the instrument. It reads temperatures directly . . . no separate conversion tables are necessary. . . . The F. & F. Pyrometer is scientifically correct, very sensitive and accurate, yet it is simple and rugged. It will withstand ordinary handling in a mill or plant. . . . . Temperature range: 1600° to 4000° F.

For Reading temperatures of metals when poured, rolled or forged

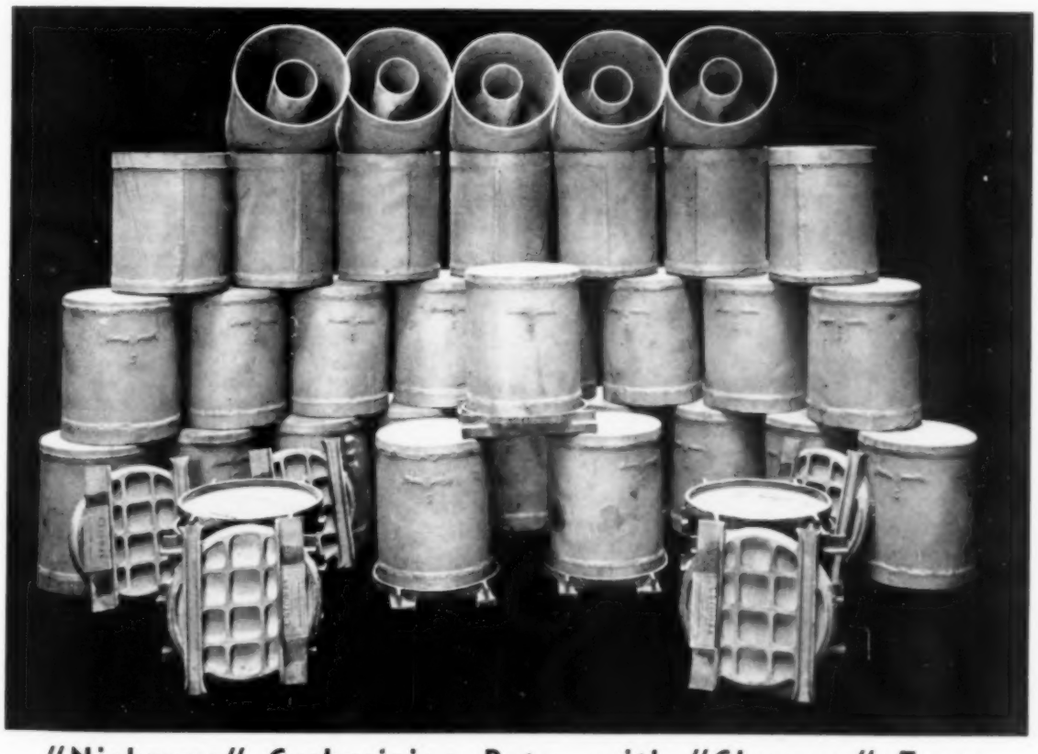
Price $175.



FISHER SCIENTIFIC COMPANY

Apparatus for the Metallurgist

PITTSBURGH, PENNSYLVANIA



"Nichrome" Carburizing Pots — with "Chromax" Trays

made by

DRIVER - HARRIS COMPANY, HARRISON, N. J.

Quenching *of* Steel..

. . . an answer to your problems

By **HERBERT J. FRENCH**
late of the Bureau of Standards, now with International Nickel Company.

THIS book is a comprehensive discussion of cooling characteristics of various cooling media (coolants). Cooling properties are given for both surface and center cooling of a given mass of steel. Data for center cooling are summarized graphically and in equations which permit computation of center characteristics of various sizes and shapes of steel.

172 pages, 6 x 9, 105 illustrations . . . bound in red cloth.

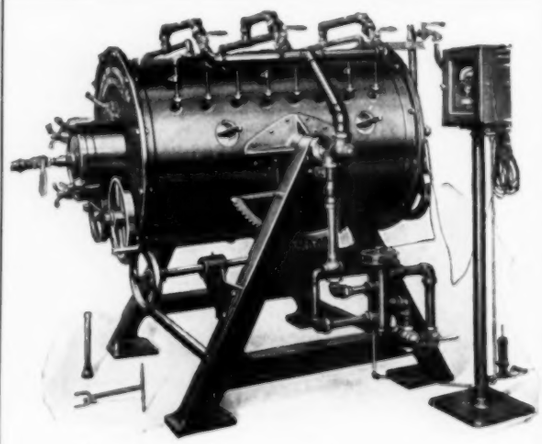
$2.50

Mail Your Order Today

ASST

American Society *for* Steel Treating

7016 Euclid Ave. Cleveland, Ohio



A reduction of 64% in cost was effected at one plant by Rotary Carburizing Machines. A more uniform product is obtained and machines have the flexibility which is so highly appreciated today.

Write for additional details.

AMERICAN GAS FURNACE CO. — PIONEERS IN 1918 — LEADERS TODAY

American Gas Furnace Co.
Elizabeth, New Jersey

CONCENTRATES

arc ("electronic tornado") mounted on a self-propelled carriage. When all seams are welded from one side the assembled unit is turned over, and the projecting bar-edges melted down during another traverse of the welding machine. This insert bar thus provides material for a slight reinforcement on the outer joint. Abutting ends of channels are staggered in the layout, and welded by hand and closed by inside butt straps, welded all around. United flanges of the channels are in effect corrugations to stiffen the shell plate longitudinally. They also give handy and frequent projections for welding to the transverse frames. Outside surfaces of the hull are smooth and leakproof; the barges do not become waterlogged and may be safely built to any desired length. Corrugated interior surfaces are not objectionable in tanker barges, nor in those for carrying sand, brick, or other deck loads.

AN amplification of Charles Pack's other papers on **PRESS CASTING** appears in *Metals & Alloys* for February, in which he gives details of his own machine for casting high melting point alloys in permanent molds under high pressure and at a speed of 2 to 5 per min. He notes that differences in temperatures prevent a close fit between plunger and the well or cylinder containing the hot metal, and that the use of packing is expensive and time consuming. He uses a cylindrical, slightly tapering well, closed at bottom by a loosely fitting plunger. Temperatures and times of operation are controlled so that when molten metal is ladled into the well a thin skull of metal chills against plunger and barrel before the plunger rises. This skull collapses and passes liquid metal into the mold, but effectively prevents leakage back around the plunger. After the casting is made, the plunger drops clear of the well, so the residue of unused metal may be cleanly removed.

RED and black stains on strip brass, expensive to eradicate and detrimental to the finished product, are caused by oxidation during

annealing and pickling, according to C. K. Skinner in April *Metal Industry*. Black oxide forms during annealing, and in electric furnaces may be prevented by the use of an air-tight chamber and controlled atmosphere. In oil-fired furnaces oxidation may be minimized by skirting the burners to exclude induced air, using a long, hazy flame, and running the heat with dampers and furnace doors closed. Red and brown **STAINS ON BRASS** are occasionally found after annealing but only when oxidation takes place at a temperature near the melting point of the metal or when traces of oils or soap solutions used as lubricants are present. When red stains are present they are usually the result of incorrect conditions in the pickling bath, but are formed only in the presence of black oxide deposited in the anneal. To prevent red stains, the solution should not exceed room temperature, the concentration of sulphuric acid should be from 2 to 10% (preferably about 6%), wash water should be free from contamination by pickling solution, and coils should be carefully opened out in the tank so that no portions of the strip lap or touch.

IN splicing lead-covered electrical cables it is important that the solder used be not only workable but gas tight as well. Six **SOLDERS** were investigated in this respect by Messrs. McLean, Peek and Schumacher (Bell System *Technical Journal* for January) who find that the plasticity of a solder in the wiping range can be used to predict its workability. The latter demands a low variation in plasticity with temperature. Porosity is caused by segregation and may possibly be related to the particle size of the solid phase at wiping temperatures. Of the compositions tested, one containing 67% Pb, 24% Sn, and 9% Cd has excellent workability and gives non-porous joints. Another containing 60% Pb and 40% Sn is nearly as good. The 65:35 lead-tin solder works easily, but frequently makes porous joints (splicers describe it as somewhat "coarse"). Another solder containing 65% Pb, 13% Sn and 22% Bi is good enough to warrant further study.

Why Char Carburizers Give Longer Carburizing Life and Lower Final Costs

★

The shell of pure carbon with which each particle of Char Carburizing Compounds is coated serves two purposes.

First, it seals the energizing material within the particle in such manner that it cannot escape.

Second, it adds to the mechanical strength of the particle, giving it greater wear resistant properties.

As a result, Char Carburizing Compounds have a very low dusting loss and give continuously uniform activity with minimun amounts of new added.

The longer carburizing life of Char Carburizers has resulted in economies ranging from 20% to 40% in plants of many large and small users.

CHAR

CARBURIZERS

for Economy and Quality Results

★

CHAR PRODUCTS COMPANY
MERCHANTS BANK BLDG. INDIANAPOLIS, IND.

VALUABLE INDUSTRIAL PUBLICATIONS

USE THE

COUPON

Circulating Oil Tempering Baths A folder recently issued by American Electric Furnace Co. describes several models of their electrically heated oil tempering baths of the circulating type. Bulletin M-2.

Thermocouple Heads Leeds & Northrup Co. offer a folder descriptive of their new Universal thermocouple heads. Photographs show simplicity of installation. Bulletin M-46.

Peroxygen Compounds A 24-page booklet issued by Roessler & Hasslacher Chemical Co. presents briefly the characteristics and uses of a number of peroxygen compounds. Bulletin M-29.

Wear and Lubricant Tester Timken Roller Bearing Co. has prepared a description of a new machine for testing load carrying capacity of lubricants, measuring friction and wear of materials. Bulletin M-71.

Continuous Furnaces W. S. Rockwell Co. Folder presents photographs and drawings of interesting installations of continuous furnaces of the pusher type. Bulletin MP-329.

Chromel Couples Hoskins Manufacturing Co. Bulletin contains technical data on pyrometer couples. Bulletin M-24.

Micro-Metallograph E. Leitz, Inc. A precision instrument for making accurate photomicrographs without distortion and with absolute flatness of field is described. Bulletin M-47.

Photographic Dilatometer R. Y. Ferner Co. Catalogue illustrates the Chevenard equipment for studying the effects of heat upon materials. Bulletin M-91.

Electric Heat Treating Furnaces—Ajax Electric Co., Inc. Photographic description of new electric furnaces for annealing wrought products, such as sheet, wire, tubing, rod, etc. Bulletin D-83.

Globar Elements and Accessories—Globar Corp. A new leaflet containing a list of standard industrial type Globar electric heating elements and a coordinated list of terminal mountings and accessories. Bulletin N-25.

Recuperators—Carborundum Co. The complete story of Carborundum Co. recuperators for industrial furnaces, describing the type and covering operating conditions. Bulletin F-57.

Quenching—A new 80-page book, "Houghton on Quenching," containing over 30 charts and photomicrographs, has just been published by E. F. Houghton and Co. MM-38.

Nitriding Steel—Properties of a new chromium-vanadium nitriding steel developed by Union Carbide & Carbon Research Laboratories are listed in a new publication of Electro Metallurgical Sales Co. MM-16.

Chrome Brick Refractories—E. J. Lavino & Co. Folder discussing chrome brick made by a new process. Test data on spalling, sagging and hot load are given. Bulletin MM-40.

Welding Electrodes—Metal & Thermit Corp. has published a folder outlining the advantages of Murex mineral coated welding electrodes. Several types of electrodes are described. MM-64.

Industrial Application of the X-Ray—General Electric X-Ray Corp. Booklet gives many examples of the use of the X-Ray in the industrial field. Profusely illustrated with radiographs of castings, welds, assemblies, etc. Bulletin D-6.

Furnaces for the Steel Industry—The Electric Furnace Co. have issued a four-page folder illustrating and listing several electric and fuel fired furnaces of various types they have installed in steel plants. Bulletin D-30.

Modern Industrial Furnaces—Surface Combustion Corp. Booklet covering the research, development and engineering activities of the Surface Combustion Corp., and their application and the advantages obtained by S-C furnace users as a result of these factors. Bulletin N-51.

Thermit Welding—Metal & Thermit Corp. A 52-page booklet on the thermit welding process and its applications. Photographs and descriptions typical of its varied uses are given, showing how Thermit is fundamentally adapted when large sections are involved. Bulletin D-64.

Gears Made of Armor Plate—The International Nickel Co. Reprint of article by Robert E. Bultman originally published in May, 1931, issue of METAL PROGRESS. Booklet deals with the use of 5 per cent nickel and nickel-chrome steels for motor truck gears and pinions. Bulletin D-45.

Hy-Ten Alloy Steels—Wheelock, Lovejoy & Co., Inc. "Pertinent Points" folders covering physical properties, heat treatment and applications of all grades of Hy-Ten Special Steels. Bulletin D-22.

Recorder Controller—Bristol Co. A new booklet describes Bristol's recently announced free vane air operated recorder controller. The instrument and its operating principles are graphically described. Bulletin JA-56.

Furnace Parts—Driver-Harris Co. has issued a bulletin featuring furnace parts made of their alloys. This bulletin gives data and advantages of Nichrome and Chromax heat resisting alloys in the form of furnace parts. Bulletin N-19.

High Frequency Induction Furnaces—Ajax Electrothermic Corp. New bulletin gives detailed information regarding Ajax-Northrup high frequency induction furnaces operated from static converters, for laboratory use or for small-scale production. Bulletin JA-41.

Conveyor Belt Handbook—Wickwire Spencer Steel Co. A new loose-leaf handbook, describing various types of metal conveyor belts for high and low temperatures. This includes the new heavy duty "Alpha" link belt, "Delta" plate belt and spiral type. Bulletin N-37.

High Test Welding Rod—The Linde Air Products Co. A 12-page booklet describing the qualities and advantages of high test welding rod. Extensively used for fabrication of pipe lines, pressure vessels or other welding operations where high strength and economy are required. Bulletin D-63.

Ingot Molds—Gathmann Engineering Co. The subject of ingot molding is covered in a new book on this subject. Numerous illustrations of the effect of various methods of finishing and casting on the reliability of steel products are given. Bulletin D-13.

Scale Prevention—Dearborn Chemical Co. Booklet describing latest scientific methods of treating water for prevention of scale, corrosion and foaming in steam boilers, dealing with related problems in connection with scale and corrosion in other power plant equipment. Bulletin D-36.

Heat and Corrosion Resistant Alloys—General Alloys Co. A new bulletin is available on chrome-nickel and straight chrome heat and corrosion resisting alloys. Bulletin D-17.

Welded Pipe—Republic Steel Corp. has prepared a booklet on its electric weld line pipe and casing. Manufacturing processes and performance data are presented. Bulletin AA-8.

Aluminum and Its Alloys—Aluminum Company of America has prepared the book "Alcoa Aluminum and Its Alloys" which presents data and tables on the physical and chemical properties of aluminum alloys. MM-54.

Neutral Atmosphere which makes possible the hardening of high speed steel without scale, decarburization or carburization, is explained by the bulletin, "The Sentry Diamond Block Method of Hardening High Speed Steel," issued by the Sentry Co. MM-84.

Optical Instruments—Bausch & Lomb Optical Co. has issued a new 128-page book, "Optical Instruments for Examining and Analyzing Metals. Information on establishing metallurgical laboratories; optical information for the metallographer; spectrographic analysis, etc. MM-35.

Fatigue Testing Machine—Thompson Grinder Co. Interesting data on fatigue testing and description of the rotating beam type of fatigue testing machine are given in Bulletin D-23.

Heat and Corrosion Resistant Alloys—Michigan Steel Casting Co. A 16-page bulletin describing and illustrating various cast, rolled and fabricated alloy structures for use at high temperatures. Bulletin N-12.

"Carbonol Process for Carburizing Steels" is the title of the new 12-page bulletin published by the Hevi-Duty Electric Co. The bulletin describes the results and advantages of the Carbonol process of carburizing. Bulletin N-44.

Welded Construction Folder—Bethlehem Steel Co. Folder describing the use of rolled steel shapes and plates for the building of machinery parts by welding. The results are said to be sturdier construction, reduced weight, low cost, and elimination of patterns. Bulletin N-76.

Machine Heat Treating—American Gas Furnace Co. A 16-page illustrated booklet giving information on the various types of conveyor heating machines available for heat treating on a production basis. Bulletin D-11.

Potentiometer Pyrometer—The Brown Instrument Co. 16-page booklet explaining and illustrating the principal features of the new Brown potentiometer pyrometer with special reference to accuracy of operation and ruggedness in service. Bulletin N-3.

Electric Steam Generators—General Electric Co. Booklet describing and illustrating G. E. electric steam generators for process work. A list of applications is included showing how these generators may be used in a wide variety of industries. Bulletin D-60.

Metal Progress, 7016 Euclid Ave., Cleveland.

Please have sent to me the following literature as described under "Industrial Publications" in the May issue of METAL PROGRESS. (Please order by number.)

.....

Name .....

Position .....

Firm .....

Address .....

Chevenard Photographic Dilatometer
Complete details in Cat. D-1

Use
CHEVENARD EQUIPMENT
to study the effects of heat on your materials

•

The
R. Y. Ferner Co.
1008 15th St. Washington, D. C

REVIEWS OF RECENT PATENTS OF INTEREST TO METAL MEN

By Nelson Littell
Patent Attorney
22 E. 40th St.
New York City
Member of A.S.S.T.

Hardening Process, *by Floyd J. Metzger, New York, N. Y., assignor to Air Reduction Co. 1,851,861; March 29.*

By this method steel can be hardened at high temperatures without the need of special apparatus for supplying gaseous ammonia and bringing it into contact with the metal articles at a high temperature. The metal articles can be buried in calcium cyanamid while they are at the necessary high temperature, or the metal articles and calcium cyanamid can be heated to the necessary temperature and steam in regulated amounts caused to come into contact with the calcium cyanamid, with the resulting generation of ammonia close to the metal surfaces. In this way, an atmosphere of ammonia is continuously generated and the operation can be continued for the necessary time by supplying enough calcium cyanamid and by introducing a regulated current of steam.

Superhard Material, *by Philip M. McKenna, Westmoreland County, Pa., assignor to Vanadium Alloys Steel Co. 1,848,899; March 8.*

The purpose of this invention is to form a material for tools, dies and similar purposes. The material described is harder than hardened high speed steel which in its hardest condition measures only about 69 on the Rockwell C scale, while the improved composition of this patent has a hardness of C-71 to C-76. The material contains from 29% to 69% by weight of tungsten metal and approximately from 71% to 31% by weight of tantalum carbide.

Copper Alloys, *by Louis P. Webert, Waterbury, Conn., assignor to American Brass Co. 1,848,858; March 8.*

The series of alloys covered by this patent are composed principally of copper and silicon, but contain additions of zinc and aluminum to produce sound, strong alloys which are highly resistant to the chemical action of certain mineral acids, organic acids and other liquids of a corrosive nature. The alloys may be prepared by melting a given weight of copper under charcoal and adding to it the required amount of silicon. When the silicon has dissolved in the copper the necessary amount of zinc is added, and then the aluminum is introduced. Some of the alloy scrap may be melted with the copper before adding the silicon, zinc and aluminum. The proportions used in the alloys are as follows: 1.0% to about 4.5% silicon, about 1.0% to about 8.0% zinc, about 0.5% to about 5.0% aluminum, manganese within the limits of 0.1 to 1.5%, and balance copper.

Pickling Machine. *by Henry C. Allman and William Leroy Davis, New Philadelphia, Ohio, assignors to American Sheet and Tin Plate Co. 1,850,488; March 22.*

A machine for pickling metal bars and sheets is described. The material to be pickled is suspended within a vat or tank containing the pickling fluid and given a reciprocatory motion to agitate the fluid so as to accelerate the washing and scouring action. It has been found that a more violent agitation or turbulency of the pickling fluid about the material can be obtained if the reciprocating motion is varied from a straight horizontal plane. In the patentee's machine this variation from a straight horizontal plane is obtained by permitting the crate with the material thereon to swing in an arc at the end of each stroke and not only is more violent agitation of the fluid obtained but less power is required in the operation. By permitting the crate to swing free at the end of each stroke the speed of reciprocation may be increased without excessive vibration and less power is required in the retarding and accelerating action at the end of each stroke.

Aluminum Alloy. *by Charles D. Russell, Sheboygan, Wis., assignor to Ruselite Corp. 1,850,517; March 22.*

One of the objects of this patent is to provide an improved aluminum alloy which possesses the desirable characteristics of high tensile strength, tenacity, and ductility, and which may be cast or worked with or without the necessity of additional heat treatment to bring out the above mentioned properties. The alloy consists mostly of aluminum, together with copper, chromium and molybdenum. Some titanium may also be employed and in the final product a small amount of iron is present in the form of an impurity. In forming the alloy, the aluminum is melted to a bright red heat. Next, calcium boron fluoride is added to act as a cover against gases which may be generated in the furnace and to prevent the aluminum from oxidizing. The copper, chromium and molybdenum are then added in order, and if titanium is employed it is then added. The molten mass is kept at a bright red heat at all times and is stirred well before being poured into molds.

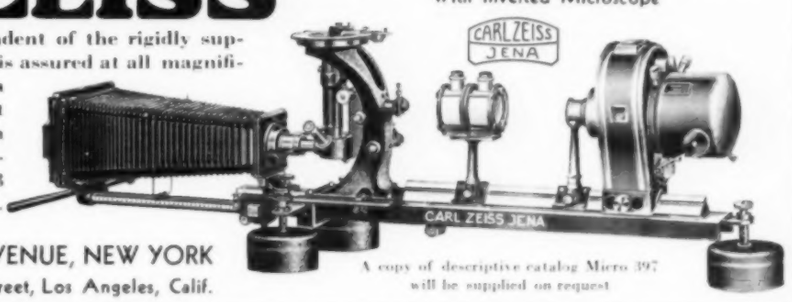
(Continued on page 90)

COMBUSTION · FURNACES
ELECTRIC · FURNACES
TUNNEL · KILNS
GAS · BURNERS
SWINDELL-DRESSLER CORPORATION
PITTSBURGH, PA.

CARL ZEISS

6½ x 8½ METALLOGRAPH
With Inverted Microscope

The focusing mechanism is independent of the rigidly supported stage, and ample steadiness is assured at all magnifications . . . Homal lenses provide for a maximum flatness of field without sacrifice of definition . . Metallograph with arc lamp, 4 apochromatic objectives, 6 compensating oculars, 3 homal lenses—$1,293.50 f.o.b. N. Y.



CARL ZEISS INC., 485 FIFTH AVENUE, NEW YORK
Pacific Coast Branch: 728 South Hill Street, Los Angeles, Calif.

A copy of descriptive catalog Micro 397 will be supplied on request

JESSOP'S

SUPERIOR OIL-HARDENING STEEL

•

NON-DEFORMING TOOL AND DIE STEEL

•

MANUFACTURED IN SHEFFIELD, ENGLAND

●

WM. JESSOP & SONS, INC.

NEW YORK 121 Varick St. | BOSTON 163 High St. | CHICAGO 1857 Fulton St. | TORONTO 59 Frederick St.

GAS

Goes to work in the —

JUTHE GAS FURNACES

(Pre-heat — High Speed)

They are noted for - -

High Efficiency
— Fuel wastage eliminated

Atmospheric Control
— Positive protection against scaling and burning

Uniform Temperature
— Perfect heat distribution

Easy Operation
— Single valve control

Ask to-day for Bulletin 16

Gas Division

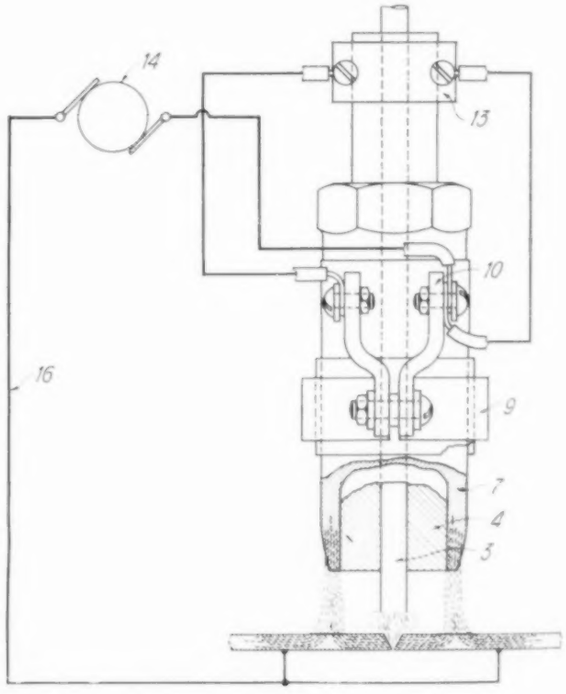
American Electric Furnace Co.

30 Von Hillern Street Boston, Mass.

Arc Welder. *by L. Andren, et al, Bridgeport, Conn., assignors to American Chain Co., Inc., 1,851,479; March 29.*

It has been found that the unsteadiness of a welding arc is to a very large extent caused by uncontrollable magnetic fluxes developed by the welding current in the metal masses of the apparatus and the work to be welded. This invention excludes the disturbing action of such magnetic fluxes by surrounding the arc with a shield of controlled magnetic flux.

In operation, current to supply the arc is fed from the generator *14* to the terminal *10*

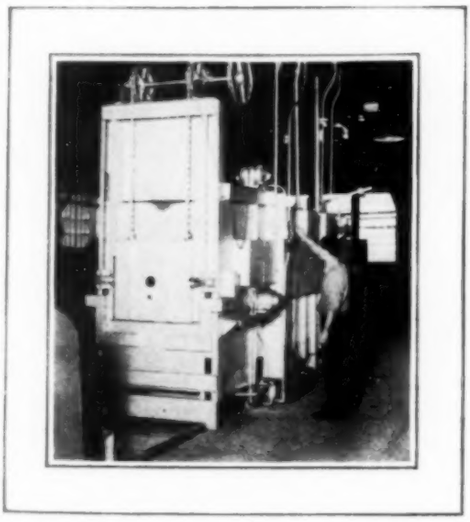


where it divides, part of it passing around the coil *9* before reaching the contact block *13*. Thence, the current flows through the nozzle *4* and rod *3* and maintains an arc between the end of the rod *3* and the work, the circuit being completed through wire *16* to the opposite pole of the generator. The current which passes through the ring *9* generates magnetic flux which flows through the shell *7* and thence jumps from the shell to the work in the form of a cylinder surrounding the arc. This cylinder of flux serves to steady the arc and protect it from outside influences. The flux supplied to the cylinder *7* is constant and serves as a stabilizer reacting on the flux generated by the arc itself and centering the arc.

A STEADY UNIFORM PRODUCER

Loading the conveyer belt of a Westinghouse Electric Furnace.

. . . *the Westinghouse Belt Conveyor Furnace*



Westinghouse Belt Conveyor Furnaces are available in several standard sizes.

CONTINUOUS, uninterrupted production with uniform heating and quenching are outstanding advantages of the Westinghouse Belt Conveyor Electric Furnace, that insure higher heat-treating efficiency and lower production costs.

All the advantages of mechanical handling and automatic control are embodied in this machine that automatically carries your small parts through the proper heating and quenching processes.

The many years of experience with industrial heating problems have enabled Westinghouse to incorporate in this heat-treating machine all the inherent advantages of electric heat.

For complete information on Westinghouse heating equipment, simply mail the coupon.

T-31888 **Westinghouse**

Quality workmanship guarantees every Westinghouse product

SEND FOR BOOKLET

Westinghouse Electric & Manufacturing Company
Room 2-N—East Pittsburgh, Pa.
Gentlemen: Please send me information on Westinghouse heating equipment.

Name .....
Company .....
Address .....
City ..... *State* ..... MP 4-32

(Continued from Page 33) and rapid evolution of heat at Ac_1 (1314° F.) and at Ar_1 (1292° F.). The small hysteresis or difference between Ac_1 and Ar_1 is notable; the Ar_1 temperature is as high as possible.

Among other things, this fact implies that the transformation in carbonyl steels (abnormal) is much faster than it is in normal steels. This is confirmed by Spenlé, working at the Technische Hochschule in Aachen, who quenched a eutectoid carbon steel (obtained by melting carbonyl iron in vacuo) and could eliminate the Ar_1' point only when the rate of cooling was at least three times as great as the rate for a crucible steel of the same analysis.

It may be objected that other investigators have shown that the solidified core zone of rimmed steel will probably be abnormal after carburizing, particularly when this kind of steel is deoxidized in the mold by adding aluminum and vanadium; furthermore, such elements as are particularly liable to cause segregation in iron, as, for instance, phosphorus and sulphur, also appear to produce abnormality.

As to the first objection, it should be remembered that the middle part of an ingot of rimmed steel, after solidification and the separation of oxides, unquestionably represents a pure iron, low in free oxygen, especially if the gas in solution in the liquid steel reacts at the last moment with deoxidizers to form rather insoluble oxides — aluminum oxide, for instance — and the aluminum is unable to react with slag or a furnace lining containing manganese and silicon. Even when heavy segregation occurs, due, for instance, to phosphorus, it is obvious that certain regions of highest purity must, or at least may, exist. It is our contention that these regions are the ones responsible for abnormal crystallization after carburization has been completed.

Another objection to the conclusion might be raised on the basis that commercial steels, when abnormal, are fine grained, whereas our samples of pure iron, also abnormal, are coarse grained. This should be sufficiently explained by the presence of the boundary films in commercial steels. The fact that abnormal behavior is typical of very pure iron probably explains why the early electric steels, which were sometimes very poor in silicon and manganese, tended to develop soft spots on being cemented and quenched, a phenomenon to which attention was directed by Kirner as long ago as 1909 in *Stahl und Eisen*.

As further evidence that the accumulation of globular cementite in abnormal steels occurs quickly at a high temperature, we have also shown that if we add transformation-retarding elements such as chromium or manganese to sintered carbonyl steels, the abnormal behavior disappears. It will be seen from Fig. 6 and 7 that a slight increase of the manganese content (from 0.06 to 0.3%) in a steel produced by melting a carbonyl iron charge suppresses the structural abnormality almost entirely. Similar experiments on sintered carbonyl steels gave similar results.

TRADE MARK

AJAX ELECTRIC COMPANY, INC.
DIVISION OF THE AJAX METAL COMPANY

ELECTRIC HEAT TREATING FURNACES
and . . .
ELECTRIC TUNNEL KILNS

Frankford Ave. & Allen St. PHILADELPHIA, PA.